## FINAL DESIGN ANALYSIS

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# CUTOFF WALLS AND CAP FOR LIME AND M-1 SETTLING BASINS

ROCKY MOUNTAIN ARSENAL **COLORADO** 



OCTOBER 1990

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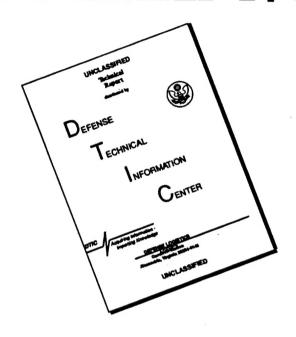


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## FINAL DESIGN ANALYSIS FOR

## CUTOFF WALLS AND CAP FOR LIME AND M-1 SETTLING BASINS ROCKY MOUNTAIN ARSENAL, COLORADO

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#### PART 1 - GENERAL DESCRIPTION

1. PURPOSE. The purpose of the project was to develop a design for the Interim Response Actions (IRA) at the Lime and M-1 Settling Basins at Rocky Mountain Arsenal (RMA), Commerce City, Colorado. The purpose of the IRA at the Lime and M-1 Settling Basins is to mitigate the threat of release from the Basins on an interim basis, pending determination of the final remedy in the Onpost Record of Decision (ROD). The IRA for the M-1 Basins also includes treatment of the waste materials in the basins with in-situ vitrification (ISV), which is being designed by contract with Woodward-Clyde Consultants.

#### AUTHORIZATION.

- 2.1 AUTHORITY. This project was authorized by DD Form 448 from Program Manager for Rocky Mountain Arsenal.
- 2.2 DECISION DOCUMENTS. Based on RMA's evaluation of the proposed alternatives, the Decision Documents were determined as shown in appendix C. The IRA for the Lime Settling Basins consists of relocation of sludge material, which has been deposited around the Lime Settling Basins, to the Lime Settling Basins area; construction of a 360-degree subsurface barrier around the basins; construction of a soil and vegetative cover over the material; and installation of a ground-water extraction system. The IRA for the M-1 Settling Basins consists of construction of a temporary 360-degree subsurface barrier such as a slurry wall or sheet pilings around the M-1 Settling Basins area, and the treatment of the waste materials in the basins with in-situ vitrification.
- 3. CRITERIA. Criteria used in the remedial design are referenced in Part 2 of this report, and are based on applicable local, state, and federal regulations.
- 4. PROJECT DESCRIPTION. The following is the project description as quoted from applicable portions of the Decision Documents for the Lime Settling Basins and M-1 Settling Basins at Rocky Mountain Arsenal.

#### 4.1. SITE NAME, LOCATION AND DESCRIPTION.

- 4.1.1. LIME SETTLING BASINS. The Lime Settling Basins are located north of the South Plants area, just north of December 7th Avenue along the southern edge of the southwest quarter of section 36. The Lime Settling Basins occupy about 5 acres. For the purpose of the alternatives assessment, it was estimated that approximately 80,000 cubic yards of sludge within the basins, plus approximately 26,000 cubic yards of sludge that had been placed adjacent to the basins for drying, would be addressed by the IRA.
- 4.1.2. M-1 SETTLING BASINS. The M-1 Settling Basins are located in the South Plants area, just south of December 7th Avenue along the northern edge of the northwest quarter of Section 1. The basins and the berms surrounding them, all of which are now buried and partially built upon, occupy an area of approximately 34,500 square feet. For the purpose of the alternatives assessment it was estimated that approximately 6,400 cubic yards of sludge plus 2,600 cubic yards of overburden would be addressed by the IRA.

#### 4.2. SITE HISTORY.

#### 4.2.1. LIME SETTLING BASINS.

- 4.2.1.1. During the 1940's and 1950's, wastewater from the production of Army agents was routinely treated prior to discharge to unlined evaporation ponds. This treatment involved the addition of lime to the wastewater to precipitate metals and reduce the arsenic concentration. Wastewaters produced in the South Plants were channeled through the Lime Settling Basins prior to gravity discharge to Basin A, just to the north. The precipitation process produced a lime sludge that contained elevated levels of heavy metals, arsenic, and mercury. Subsequent discharges of pesticide production wastewater resulted in the addition of pesticide to the Lime Settling Basins sludge. The Lime Settling Basins were taken out of service in 1957.
- 4.2.1.2. A number of studies have been completed to characterize the nature and extent of contamination in the soil, sludge, and ground-water in the vicinity of the Lime Settling Basins. These studies are referenced in the Decision Document and the results are consistent with the site history. The soil and sludge contain elevated levels of organochlorine pesticides, organosulfur compounds, arsenic, mercury, and ICP metals (cadmium, chromium, copper, lead, and zinc).

#### 4.2.2. M-1 SETTLING BASINS.

- 4.2.2.1. The M-1 Settling Basins were constructed to treat fluids form the lewisite facility. Two basins were constructed in 1942, and a third was constructed in 1943 when the original two filled with solids. All three were unlined, and each measured approximately 90 feet wide, 115 feet long, and 7 feet deep. In addition to the waste fluids from the lewisite disposal facility, the basins may have contained lesser amounts of waste materials from alleged spills within the acetylene generation building, the thionyl chloride plant, and the arsenic trichloride plant, which may have been routed through floor drains and the connecting piping to the basins. The basins also received a considerable amount of mercury chloride catalyst, possibly from a spill.
- 4.2.2.2. The liquids discharged into the basins first passed through a set of reactor towers where calcium carbonate was added, then through a wood trough into the M-1 Settling Basins where the arsenic precipitated out of solution. The liquid from the settling basins was decanted through an 18 inch diameter pipe to the Lime Settling Basins where final treatment occurred, before being routed to Basin A. The M-1 Settling Basins were backfilled, probably in 1947, and are now covered with soil. Portions of the basins are covered with structures. These structures will be relocated as part of this IRA before implementation of the ISV treatment.
- 4.2.2.3. Based on several investigations, the contaminants in the waste material in the M-1 Settling Basins are primarily arsenic (about 8 percent) and mercury (about 0.5 percent), with the bulk of the material being oxides or carbonated of calcium. Organochlorine pesticides and other organics have also been found in the near-surface soils. The bottoms of the basins appear to be about 7 feet below ground surface, based on as-built drawings and field investigations.

#### PART 2 - DESIGN REQUIREMENTS AND PROVISIONS

#### GEOLOGY.

#### 1.1 GENERAL GEOLOGY.

- 1.1.1 Physiography. The Rocky Mountain Arsenal (RMA) lies within the Colorado Piedmont section of the Great Plains physiographic province. This area is characterized by surface deposits of wind-blown and alluvial materials. The Arsenal lies near the eastern edge of the valley along the South Platte River. The topography of the Rocky Mountain Arsenal area consists of gently rolling hills with occasional prominent hills which contain bedrock outcrops.
- 1.1.2 Description of Overburden. Overburden in the Rocky Mountain Arsenal area consists of both alluvial and eolian deposits of silts, clays, sands, gravels and a few cobbles.
- 1.1.2.1 There are several distinct deposits that make up the overburden that have been identified in the Rocky Mountain Arsenal area. The Quaternary units, from oldest to youngest, include the Verdos, Slocum, Louviers, Broadway, unnamed loess, unnamed eolian, Piney Creek, and Post Piney Creek. The older alluvium is primarily coarse-grained sands and gravels whereas the younger alluvium and the eolian deposits are primarily finer grained materials. The alluvial materials were deposited in irregular, braided channel environments creating typical lenticular deposits. The eolian materials are generally silts and fine sands. The thickness of these deposits in the vicinity of the Rocky Mountain Arsenal varies from 130 feet thick to less than 20 feet. These materials are generally unconsolidated and lie unconformably on the Cretaceous-Tertiary Denver Formation.
- Bedrock Stratigraphy. The bedrock unit lying directly below 1.1.3 the Quaternary alluvium is the Denver Formation. Immediately underlying the The thickness of the Denver Denver Formation is the Arapahoe Formation. Formation in the vicinity of the Rocky Mountain Arsenal varies from 200 to 500 Denver Formation was derived from the erosion of basaltic and aesthetic material and was deposited by fluvial processes. The Denver Formation consists of units of interbedded siltstones, claystones, sandstones and lignite. A low permeability volcaniclastic layer is present in the upper portion of the This volcaniclastic layer contains lithic fragments and minerals in a bentonitic clay matrix which probably is the product of a weathered Sandstone layers of the Denver Formation are usually volcanic ash deposit. discontinuous, lense-shaped and generally grade laterally and vertically into The lignite layers are more continuous than the shales and siltstones. sandstone layers and are usually fractured.
- 1.1.4 Bedrock Structure. The Rocky Mountain Arsenal facility lies in the northwestern portion of the Denver Basin. The Denver Basin is an extensive, oval-shaped, structural depression extending from eastern Colorado and eastern Wyoming into western Kansas and western Nebraska. The sedimentary rocks that fill the Denver Basin are predominantly shales, sandstones, conglomerates and occasionally some limestones. The gently dipping slope of

shallow bedrock formations of the Denver Basin is one degree or less in the vicinity of the Rocky Mountain Arsenal and is predominantly to the southeast.

#### 1.2 INVESTIGATIONS SUMMARY.

- 1.2.1 General. Pre-design investigations consisted of review of IR and IRA reports and field investigations of both the Lime and M-1 Basin areas. The field investigations included topographic surveys, drilling, sampling, and permeability testing for geotechnical and chemical testing. Corps personnel visited the Arsenal to observe, photograph, and quality check the Contractor.
- 1.2.2 Topographic Surveys. In order to develop existing site conditions, a topographical survey was conducted to establish horizontal and vertical control. Subsequent mapping was prepared. The mapping, which contains all topographic features, was drawn at 1"=50' for the Lime Basins Area, and at 1"=20' for the M-1 area. A 1 foot contour interval was used. The survey was also used to determine the field locations of the Lime Settling and M-1 Basins. Since the M-1 Basins are buried, stakes were placed at the boundaries. The locations were determined from as-built drawings and reviewing aerial photography.
  - 1.2.3 Exploration Drilling for Lime Settling Basins.
    - 1.2.3.1 Equipment and Personnel.
    - 1.2.3.2 Boring Locations and Purpose.
    - 1.2.3.3 Slug Tests.
    - 1.2.3.4 Backfilling Holes.
  - 1.2.4 Exploration Drilling for M-1 Basins.
    - 1.2.4.1 Equipment and Personnel.
    - 1.2.4.2 Boring Locations and Purpose.
    - 1.2.4.3 Backfilling Holes.

#### 1.3 SITE GEOLOGY.

- 1.3.1 Lime Settling Basins.
- 1.3.1.1 Bedrock. Bedrock beneath the Lime Settling Basins area is the Cretaceous-Tertiary Denver Formation. The unconformable contact between the bedrock and the overlying surficial deposits is irregular due to erosion of the surface of the bedrock prior to the deposition of the surficial material. The uppermost portions of the Denver Formation are weathered and often fractured.
- 1.3.1.1.1 Lithology. The Denver Formation in the vicinity of the Lime Settling Basins consists of claystone and sandstone. The claystone

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Changes for the 90% Design Analysis, dated October 1990: See page 2-2, delete paragraph 1.2 in its entirety and substitute the following.

#### 1.2 INVESTIGATIONS SUMMARY.

- of IR and IRA reports and field investigations of both the Lime Settling Basins and M-1 Basin areas. The field investigations included topographic surveys, drilling, and sampling, for geotechnical and chemical testing and insitu permeability testing. Topographic surveys were conducted by Government personnel. Drilling, sampling and permeability testing was accomplished under contract with Woodward Clyde Consultants (WCC). Omaha District personnel visited the work site to oversee the work of the contractor. The discussion of the drilling, sampling, and permeability testing is a summary of the work done by WCC. A complete discussion of the field investigations performed by WCC is included in their report "Field Investigation, Lime and M-1 Settling Basins Slurry Walls, Rocky Mountain Arsenal, Commerce City, Colorado" dated September, 1990, Volumes I and II.
- 1.2.2 Topographic Surveys. In order to develop existing site conditions, a topographical survey was conducted to establish horizontal and vertical control. Subsequent mapping was prepared. The mapping, which contains all topographic features, was drawn at 1"=50' for the Lime Basins Area, and at 1"=20' for the M-1 area. A 1 foot contour interval was used. The survey was also used to determine the field locations of the Lime Settling and M-1 Basins. Since the M-1 Basins are buried, stakes were placed at the boundaries. The locations were determined from as-built drawings and reviewing aerial photography.
- 1.2.3 Exploration Drilling for Lime Settling Basins. Field investigations for the Lime Settling Basins were conducted by WCC during June and July 1990. Field investigations consisted of electro-magnetic surveys for locating buried metallic objects, exploratory drilling, slug tests for hydraulic conductivity analysis, ground-water sampling, soil sampling and analyses, and bulk sampling for compatibility testing and borrow area analysis. All drilling except the borrow investigations was conducted in level B protection.
- 1.2.3.1 Equipment and Personnel. Drilling was accomplished by Layne-Western Co. under contract to WCC. Drilling and sampling was accomplished by drilling with 6 1/4-inch OD hollow stem augers using a CME 75 or CME 750 drilling rig. The majority of samples were obtained by a 3-inch OD, stainless steel split spoon driven by a 140-pound hammer. Continuous auger cores were taken of bedrock in polybutyrate tubes. Logging and sampling of borings were done by WCC personnel.

- borings were drilled for the investigation of the Lime Settling Basins
  Project. Nineteen borings were drilled along the alignment of the slurry
  trench to identify the subsurface materials and to determine the consistency
  density and moisture content of the overburden, and the nature and
  characteristics of bedrock including degree of weathering, fracturing, and
  cementation, and relative hardness. Eight borings were drilled outside the
  slurry trench area to determine the extent of waste material that hand been
  removed from the Lime Settling Basins. Three wells were installed inside the
  slurry trench area for slug tests to determine the hydraulic conductivity of
  the overburden aquifer. Samples were taken from all borings for geotechnical
  analyses; compatibility testing; and chemical analyses.
- Slug Tests. Slug tests were conducted in 1.2.3.3 wells installed in borings LSB-15, LSB-34, and LSB-35 on 24 and 25 July 1990. These slug tests were conducted to ascertain the hydraulic conductivity of the overburden aquifer within the isolation cell, particularly for the design of the ground-water extraction system. The wells were constructed of 4-inch ID PVC riser pipe and 10 feet of slotted PVC casing used for the well screen. The bottom of the screens were placed at the top of bedrock. The screens were sand packed to the top of the aquifer then sealed with hydrated bentonite pellets and bentonite grout to the ground surface. The wells were developed with a 3-inch diameter steel surge block. After development the wells were allowed to recover two weeks before initiation of the slug tests. Slug tests were conducted using an automated data logger, 10-psi range pressure transducer probe, and a 5-foot long slug constructed of PCV pipe filled with sand and capped at each end. A falling head slug test and a rising head slug test were conducted in each well. The tests were continued until 90 percent of the induced head change was dissipated. Data and analysis of the slug tests are included in appendix A.
- 1.2.3.4 Backfilling Holes. All holes were backfilled with grout after completion.
- 1.2.4 Exploration Drilling for M-1 Basins. Field investigations were also conducted in July 1990. With the exception of slug tests, field investigations were identical to those conducted at the Lime Settling Basins.
- 1.2.4.1 Equipment and Personnel. Equipment and personnel involved in field investigations for the M-1 Basins were essentially the same as those at the Lime Settling Basins.
- 1.2.4.2 Boring Locations and Purpose. A total of 29 borings were drilled for the investigation of the M-1 Basins. Of these 12 were drilled for the design of the sheet pile wall, 2 were drilled for background geological information, and 15 were drilled within the basins to obtain data for the design of the in-situ soil vitrification project, primarily to characterize the waste sludge. As for the Lime Settling basins borings, borings drilled along the alignment of the sheet pile wall were drilled to determine the nature and character of the overburden and bedrock materials.
- 1.2.4.3 Backfilling Holes. All exploratory borings were backfilled with grout after completion.

- is generally soft to moderately hard, brown, and blocky and is occasionally silty. Sandstone lenses are also frequently encountered. The sandstone units are fine-grained and vary from soft to hard, depending upon the degree of cementation and weathering, and fine grained. These sandstones also contain silt, thus making them less pervious. A thick, up to 15 feet, fine-grained sandstone lense occurs in the northern section of the isolation cell.
- 1.3.1.1.2 Bedrock Topography and Structure. The Denver Formation bedrock lies at depths of 13.5 to 27.5 feet below the surface in the Lime Settling Basins area. The local slope of the surface of the bedrock is very gentle, about two degrees, to the north-northeast. It also displays paleochannel valleys and benches. This type of paleotopography is due to stream erosion. The dip of the Denver Formation has not been determined, but it is probably the same as the regional dip, about one degree or less to the southeast. A bedrock contour map is included in Appendix A.
- 1.3.1.2 Overburden. The overburden in the Lime Settling Basins area is of Quaternary age and is the result of deposition by the ancient Platte River drainage network and eolian processes.
- 1.3.1.2.1 Lithology. The thickness of the overburden ranges between 13.5 and 27.5 feet in the Lime Settling Basins area. The soils consist mostly of poorly graded, silty, fine-grained sand with moderate amounts of sandy, silty clay and minor amounts of clayey sand, sandy clay, silty clay, and clay. The sand ranges from loose to dense and the clay ranges from soft to very stiff. The overburden soil ranges from dry to saturated with moisture content increasing with depth.
- 1.3.1.2.2 Alluvial Aquifer Material. The aquifer material is generally unconsolidated, fine-grained sand or silty, fine-grained sand, and clayey fine-grained sand overlying the top of bedrock. The saturated thickness ranges from 9.5 to 21.0 feet.

#### 1.3.2 M-1 Basins.

- 1.3.2.1 Bedrock. The bedrock beneath the M-l Settling Basins area is the Cretaceous-Tertiary Denver Formation. The unconformable contact between the bedrock and the overlying surficial deposits is irregular due to erosion of bedrock prior to the deposition of the surficial material. The uppermost portions of bedrock are weathered and often fractured.
- 1.3.2.1.1 Lithology. The upper portion of the bedrock is weathered, soft to moderately hard, dark brown claystone occasionally interbedded with moderately hard to hard, fine-grained sandstone and sandy siltstone.
- 1.3.2.1.2 Bedrock Topography and Structure. The Denver Formation bedrock is located at depths of 9.0 to 14.5 feet below the surface in the M-1 Settling Basins area. The slope of the surface of the bedrock is very gentle, less than one degree to the north. The bedrock surface was shaped by stream erosion. As at the Lime Settling Basins, the dip of the Denver Formation probably coincides with the regional dip of one degree or less to the southeast.

- 1.3.2.2 Overburden. The overburden material in the M-1 Settling Basins area is of Quaternary age and is the result of deposition by the ancient Platte River drainage network and eolian processes.
- 1.3.2.2.1 Lithology. The overburden in the M-1 Basins area is 9.0 to 14.5 feet in thick. The material consists mostly of unconsolidated, fine-grained, yellowish to grayish brown sand and silty sand with silt and clay of alluvial or eolian origin; surficial fill material; and chemical waste sludge. The fill extends from the ground surface downward, ranges from 2 to 11 feet thick and consists mostly of a mixture of clay, sand, and gravel occasionally mixed with sandstone and claystone. The chemical waste sludge ranges from 3.0 to 6.5 feet thick. Overburden ranges from dry to saturated with moisture content increasing with depth.
- 1.3.2.2.2 Aquifer Material. The aquifer material in the M-1 Basins consists of alluvial and eolian materials which are unconsolidated, poorly graded, fine grained sand and occasional silt. Saturated thickness ranges from 3.0 to 4.5 feet.

#### 1.4 HYDROLOGY.

- The Rocky Mountain Arsenal lies within Regional Hydrology. 1.4.1 the drainage basin of the South Platte River. The South Platte River is approximately 3 miles west and northwest of the Arsenal. Ground-water flow in the Arsenal area is from southeast to northwest eventually discharging into the Ground water in the overburden is generally unconfined South Platte River. while ground-water in the bedrock units is confined. Ground water is unconfined. where permeable bedrock units are exposed at the surface or in contact with the The aguifer units of greatest concern in the Rocky Mountain Arsenal vicinity are in the surficial Quaternary overburden deposits and permeable sandstones of the underlying Denver Formation. The bottom portion of the Denver Formation is a "buffer zone" of shale. This buffer zone is approximately 75 to 200 feet thick and acts as an aquitard between the Denver Formation and the lower bedrock formations of Arapahoe, Laramie Formation, Fox Hills Sandstone and the Pierre Shale.
- 1.4.1.1 Bedrock. Confined aquifers in the Denver Formation exist in the more permeable sandstones and lignite beds. These beds are separated from the overlying alluvial aquifer by shale or claystone. The Arapahoe Formation underlies the Arsenal area at a depth of 200 to 500 feet below the ground surface. Due to high-volume ground water withdrawals from the Arapahoe Formation over the past 100 years, the vertical gradient between the Denver and Arapahoe Formations in the vicinity of the Rocky Mountain Arsenal has changed from upward to downward. Recharge of the bedrock aquifers occurs from vertical leakage from the alluvial aquifers.
- 1.4.1.2 Overburden. Unconfined ground-water occurs in unconsolidated surficial alluvium or eolian deposits of sand. Ground-water flow in the alluvium is most rapid through coarse materials found in paleochannels, however, flow does occur throughout the saturated thickness of the overburden deposits. Thick, saturated alluvial deposits are capable of yielding large volumes of water.

#### 1.4.2 Site Hydrology.

#### 1.4.2.1 Lime Settling Basins.

1.4.2.1.1 Bedrock. The Denver Formation is saturated below the Lime Settling Basins and contains some confined aquifers. The most conductive units are generally subhorizontal layers of sandstones and siltstones confined by less permeable claystones. The ground-water flow in the bedrock aquifers is believed to be due north.

for the Denver Formation aquifers vary both vertically and horizontally based on lithology and the degree of weathering and fracturing. Shales and claystones have a reported hydraulic conductivity ranging from 3.53 x  $10^{-6}$  to 3.53 x  $10^{-8}$  cm/sec. Unfractured claystones may be as low as 3.53 x  $10^{-12}$  cm/sec (Stollar and Assoc. 1989). A conservative value of 1.0 x  $10^{-8}$  cm/sec for the vertical hydraulic conductivity for the claystone was used in calculations for this project. The hydraulic conductivities of the various sandstones have been reported to range from 1.06 x  $10^{-5}$  to 1.41 x  $10^{-3}$  cm/sec (Stollar and Assoc. 1989).

1.4.2.1.2 Overburden. The Lime Settling Basins are situated in a local topographic low area. The Lime Settling Basins are hydrogeologically downgradient from the M-1 Settling Basins and the South Plants area. The ground-water flow direction is about due north with a gradient of 0.023 ft/ft. There is ponded water inside the lime settling basins and it has been determined that the ponded water reflects the water table.

1.4.2.1.2.1 Hydraulic Analysis. Slug tests were conducted to determine the hydraulic conductivity for the fine-grained materials in the overburden at the Lime Settling Basins. Three slug tests were conducted, with one test conducted near the center of the isolation cell and the other two conducted 100 feet south of the north wall of the isolation cell. The hydraulic conductivity near the center of the isolation cell was determined to be 2.0 x  $10^{-3}$  cm/sec. The two tests 100 feet south of the north wall indicated hydraulic conductivities of  $1.0 \times 10^{-4}$  cm/sec and  $2.0 \times 10^{-4}$  cm/sec. In order to perform conservative analyses for the design of the project the lowest hydraulic conductivity was used in all calculations. Review of boring logs and mechanical analyses of samples obtained during the exploration program support the use of the smallest value obtained from the slug tests. Data and analysis of the slug test are included in Appendix A.

#### 1.4.2.2 M-1 Basins.

1.4.2.2.1 Bedrock. The Denver Formation is saturated below the M-l Basins and may contain some confined aquifers. Subhorizontal layers of sandstones and siltstones, confined by less permeable claystones, are generally the most permeable units of the Denver Formation. Ground-water flow within these aquifer units is generally due north.

- 1.4.2.2.1.1 Hydraulic Analysis. The aquifers within the Denver Formation have hydraulic conductivities that vary both vertically and horizontally based on lithology. The claystones and shales have reported hydraulic conductivities ranging from 3.53 x  $10^{-6}$  to 3.53 x  $10^{-8}$  cm/sec. The sandstones have a reported hydraulic conductivity ranging from 1.06 x  $10^{-5}$  to 1.41 x  $10^{-3}$  cm/sec. The uppermost unit of the Denver Formation below the M-1 Basins is claystone.
- 1.4.2.2.2 Overburden. Paleotopographic influences and localized mounding of ground-water direct the flow of ground-water in the M-1 Basins area due north to slightly northwest. The ground-water gradient ranges from 0.008 to 0.011 ft/ft. The water table varies seasonally between 5 and 10 feet below ground surface. Current water levels range from 7.8 to 10.0 feet below ground surface. The thickness of the saturated zone ranges from about 3.0 to 4.5 feet.
- 1.4.2.2.2.1 Hydraulic Analysis. The hydraulic conductivities for the overburden aquifer has been reported as ranging from 6.0 x  $10^{\text{-3}}$  cm/sec to 2.4 x  $10^{\text{-3}}$  cm/sec.

#### 1.5 CONTAMINATION.

#### 1.5.1 Lime Settling Basins.

- Soils. Soil contamination at the Lime Settling Basins has been investigated previously. Contaminants detected have included raw materials, such as mustard agent-related compounds, manufacturing by-products, such as volatile aromatic solvents, and degradation products from the synthesis Previous borings indicate detectable concentrations insecticides. organochlorine pesticides (OCP's). The following OCP's were detected: dieldrin, with concentrations from 0.6 to 70  $\mu$ g/g, aldrin, with concentrations up to 600 concentrations up to 200  $\mu g/g$ , and isodrin, with  $\mu$ g/g, endrin, with concentrations up to 300  $\mu$ g/g. Other contaminants found were organosulphur compounds of chlorophenylmethyl sulfide, chlorophenylmethyl sulfoxide, and chlorophenylmethyl sulfone with concentrations up to 50  $\mu g/g$ . DDT was also found in an isolated area with a concentration of 7  $\mu$ g/g. Volatile organic compounds (VOC's) were detected in some of the previous deeper borings. Chloroform was detected at concentrations ranging from 2 to 7  $\mu$ g/g. Benzene was detected at concentrations ranging from 5 to 6  $\mu \mathrm{g/g}$  and chlorobenzene was detected at a concentration of 2  $\mu$ g/g. The most prevalent metals were arsenic and mercury. Arsenic concentrations were detected as high as 370  $\mu$ g/g. Mercury was detected at concentrations of 0.159  $\mu$ g/g. Elevated concentrations of copper, lead, zinc, cadmium, and chromium were also detected. Tetrachloroethene was also detected at a concentration of  $0.25 \mu g/g$ .
- 1.5.1.2 Ground Water. Ground-water contaminants in the alluvial aquifer have been detected at the Lime Settling Basins site during previous investigations. These contaminants include VOC's (volatile organic compounds), aromatics, metals, and OCP's (organochlorine pesticides). High concentrations of various VOC's were detected. Arsenic, mercury, chromium, and copper were metals that were detected from previous monitoring well samples.

#### 1.5.2 M-1 Basins.

- 1.5.2.1 Soils. High concentrations of arsenic and mercury were found in and around the M-1 Basins from depths of 0.5 to 7.0 feet. The concentrations within the basins ranged from 0.01% to 11%. These concentrations generally decreased below the 7-foot depth. Dieldrin, DCPP and BCHPD have also been reported in significant concentrations.
- 1.5.2.2 Ground water. Previous investigations indicate high concentrations of arsenic and mercury are present in the ground water downgradient of the M-1 Settling Basins.

#### 2. SLURRY TRENCH CUTOFF WALL (LIME SETTLING BASINS).

- 2.1 Criteria. The Decision Document for the Lime Settling Basins requires the containment system consist of a 360 degree subsurface barrier, vegative cover, ground-water removal system to maintain a negative head in the isolation cell, evaluation of ground-water diversion, and evaluation of potential contamination of bedrock aquifers.
- 2.2 References. The following references were used during the design process:

EPA-540/2-84-001, Slurry Trench Construction for Pollution Migration Control.

 $\,$  EPA 600/2-87-063, Investigation of Slurry Wall Design and Construction Methods for Containment of Hazardous Waste.

Millet and Perez, "Current USA Practice: Slurry Wall Specifications", ASCE Journal of Geotechnical Engineering, August 1981.

D'Appolonia, "Soil-Bentonite Slurry Trench Cutoffs", ASCE Journal of Geotechnical Engineering, April 1980.

ASTM STP 874, Hydraulic Barriers in Soil and Rock, 1985.

Xanthakos, Slurry Walls, 1979.

Zappi, Shafer, and Adrian, "Compatibility of Soil- Bentonite Slurry Wall Backfill Mixtures With Contaminated Ground-water", Proceedings of Superfund '89 Conference, HMCRI, November 27-29, 1989.

Schulze, Barvenik, and Ayres, "Design of Soil-Bentonite Backfill Mix for the First Environmental Protection Agency Superfund Cutoff Wall".

API RP 13B-1, API Recommended Practice: Standard Procedure for Testing Drilling Fluids.

API Spec. 13A, API Specification for Oil Well Drilling Fluid Materials.

Plans and Specifications, Helen Kramer Landfill Superfund Site, Mantua Township, New Jersey, prepared by the Kansas City District

Plans and Specifications, Kane and Lombard Superfund Site, East Baltimore, Maryland, prepared by EA Engineering Science and Technology Inc.

2.3 Compatibility Study. The presence of chemical contaminants in soil and/or ground-water may significantly alter the rate of water movement through a soil medium. The purpose of compatibility testing is to find the mixture of backfill soil, bentonite, and tap water which will produce the lowest permeability of contaminated ground water over time. The Missouri River Division

(MRD) Laboratory in Omaha will perform the compatibility studies. The lab test request is included in Appendix A. The original request is dated 23 August 1990. On 1 October 1990, MRD lab personnel proposed changes in the testing procedure based on preliminary results of a similar compatibility study presently being conducted for the Forest Waste Superfund Site. The updated test request (dated 10 October) reflects the changes. The updated procedure is described here. After selection of a bentonite source using the free swell and filter cake compatibility tests, optimization testing (one or two-day fixed wall permeability tests) determines the most economical combination of bentonite, backfill soil, and water which yields a permeability of 1 x 10<sup>-7</sup> cm/sec or less. That combination is used in permeameter tests utilizing both contaminated ground-water and tap water.

2.3.1 Bentonite Sources. Several drillers supply companies in Colorado and two out-of-state companies were contacted to identify potential bentonite suppliers and to obtain samples for conducting compatibility studies. Samples from the following companies were sent to the MRD Laboratory:

Golden Drilling Fluids and Supplies Inc. Golden, CO Regular

Dean Bennett Supply Company Denver, CO Mudgel

H & H Bentonite and Mud Inc. Grand Junction, CO BH-Natural and AS 85

Black Hills Bentonite Company Palatane, IL S-5 Natural

Wyo-Ben Inc. Billings, MT Hydrogel

The free swell test (EPA Report Number PB 87-229688) and filter cake compatibility test will be used to select the bentonite for this project. Two free swell tests will be performed for each bentonite sample; one using contaminated ground-water and one using RMA tap water (see following paragraph). The bentonite which exhibits the least amount of variation between the tap water and contaminated ground-water test will be selected for the backfill mixtures.

2.3.1.1 Natural vs. Treated Bentonite. The Corps slurry trench guide spec (several years old) specifies natural bentonite only. However, many slurry trench references (EPA-540/2-84-001, Millet and Perez, D'Appolonia, Xanthakos) say that practically all commercially available bentonite contains chemical additives; it is more a matter of how much is added. A memo from Geo-Con Inc., the Kane and Lombard contractor (included in Appendix A) states that most slurry trench specifications allow treated bentonites which conform to API

- Spec 13A Section 4 to be used. On the Kane and Lombard project only natural bentonite which conforms to API Spec 13A Section 5 (a new section) was allowed. Geo-Con experienced some problems during construction that they attribute to the natural bentonite. He recommends not using API 13A Section 5 natural bentonites for slurry trenches. Due to time constraints in both this project and the Forest Waste project it was decided to stick with the Corps spec and use only natural bentonites. In the future when time becomes available the MRD lab may do some comparisons between natural and treated bentonites to address this question. Of the bentonites sent to the MRD lab, only 2 (H & H Bentonite's BH-Natural and Black Hill's S-5 Natural are API 13A Section 5 natural and only those two will be used for testing.
- 2.3.2 Water Samples. To simulate field conditions at the Arsenal site, samples of tap water and contaminated ground water were collected during the pre-design field investigations. Tap water will be used to mix the slurry and backfill materials and ground water will be used as a permanent.
- Two backfill soils will be tested; the 2.3.3 Backfill Soil Samples. soil to be excavated from the trench and soil from an uncontaminated borrow area Soil from the trench alignment has been collected as part of on the arsenal. the pre-design field investigations. After screening for Army agents, samples from the borings located on the northern half of the slurry trench cell were composited and tested for grain size distribution, Atterberg limits, and water This soil was sent to the MRD Lab for compatibility content at the Arsenal. Prior to the pre-design field investigations it was decided to use soil from the northern boundaries of the trench for compatability studies. This is because the groundwater flow in the area is toward the north and the highest levels of contamination found in the previous studies is to the north of the Lime Basins; therefore that soil should provide the "worst case" testing condition. The boring logs along the trench alignment are very consistent: fill or sludge overlying SM (USCS classification), overlying CL-CH, overlying claystone. mechanical analyses of the composited samples are also very similar, containing between 17 and 40 percent fines. Due to the overall consistency and the desire to use mostly soil from the northern boundaries while also assuring representative samples, it was decided to thoroughly mix samples from the following borings into one composite: 9, 10, 17, 22, 23, 24, 25 and 26. represent all borings along the northwest, north, and northeast boundaries of the isolation cell.
- 2.3.3.1 Borrow Materials. Corps personnel decided to use a clay borrow area used in the remediation of Basin F. Four test pits were excavated in this area. Approximately 150 pounds of soil was collected and sent to the MRD Lab. As there is a limited amount of this material available, this soil will be used as a possible source of fines only and not the primary borrow material. This material classifies as CL, with a liquid limit of 34.6, plastic limit of 13.5, plasticity index of 21.1, and 69.9% finer than the No. 200 sieve. (Laboratory classification data received to date are in Appendix A). Stockpiles of soil excavated from the spillway construction at the Lower Derby Dam on the Arsenal will be used as the primary alternate borrow. Samples of this material were brought to the MRD lab on August 31, 1990 and will be tested for grain size distribution, Atterberg limits and moisture content prior to optimization testing.

- 2.3.3.2 Chemical Screening of Borrow. Prior to compatibility studies, both borrow soils will be tested for TCLP (Toxicity Characteristics Leaching Procedure), TOC (Total Organic Carbon), sodium, calcium, magnesium, potassium, pH, and cation exchange capacity.
- 2.3.4 Sample Preparation. The backfill soil samples will be oven-dried at 65 degrees Celsius for 2 to 4 days. The soils will then be broken up, thoroughly mixed, and passed through a U.S. Standard Sieve No. 4. The RMA tap water shall be added to the dried and mixed samples until the original field water content is reached. These reconditioned composite samples shall then be stored for 3 to 6 days in sealed containers at room temperature. During this storage period the samples will be mixed daily.
- 2.3.4.1 The bentonite slurry shall be prepared by mixing the RMA tap water with the previously selected bentonite source. The slurry shall be mixed with enough water to pass through a Marsh funnel in 40 to 50 seconds. The slurry shall be tested for density, water content, pH, viscosity, and fluid loss.
- 2.3.5 Optimization Testing. Short-term (1 or 2 days) permeability tests will be performed to determine the most economical combination of bentonite, water, fines and coarse grained soil with a permeability of 1 x  $10^{-7}$  cm/sec or less. Since tap water and backfill soil are available on the Arsenal, it is anticipated bentonite will be the highest cost item.
- 2.3.5.1 Three samples (two specimens each) of the insitu slurry trench soil will be prepared containing 0, 2, and 4 percent dry bentonite by weight. Bentonite slurry with a viscosity of 40 seconds (Marsh funnel) will be added to each sample to obtain an approximate 5 inch slump. Fixed wall permeability tests will be run on the 6 specimens. "Total Percent Bentonite vs. Permeability" will be plotted. If permeability values are not less than or equal to 1 x 10EE-7 cm/sec, the above procedure will be repeated with the addition of enough clay borrow soil to make the fines content approximately 10 percent higher than the original insitu composite. If those permeability values are not less than or equal to 1 x 10EE-7 cm/sec, the procedure will be repeated with the addition of clay borrow soil to make the fines content approximately 20 percent higher than the original insitu composite. If permeability values are still too high, the procedure will be repeated with the addition of clay borrow to make the fines content approximately 30 percent higher than the original insitu composite.
- 2.3.5.2 The optimization testing procedure will also be performed using the random fill borrow soil in place of the insitu soil. Due to the presence of contaminants in the insitu soil there is a possibility that none of the mixtures of insitu soil, fines and bentonite will produce a permeability on the order of magnitude of 10EE-7 cm/sec. If this happens and a mixture of random fill, fines, and bentonite produces an acceptable permeability then only random fill borrow will be used for construction, and long-term permeability tests will be performed using only random fill borrow as the principal soil constituent. If the desired permeability is obtained by mixtures including both insitu soil and random fill borrow then long-term permeability tests will be performed using

both principal soil constituents, and the decision of which soil to use for construction will be made based on the results of those tests.

- 2.3.6 Permeameter Sample Preparation. Samples for long-term permeability tests will be prepared according to subparagraph 2.3.4, Sample Preparation. The backfill mixtures shall be stored in sealed containers at room temperature until loading into the permeameters for permeability testing. Atterberg limits, fines content, porosity, density, water content, specific gravity, cation exchange capacity, and pH of the backfill mixtures will be determined. Before the backfill materials are loaded into the permeameters, comments on the general appearance, i.e. color and texture of the material before permeameter testing shall be recorded. The backfill materials and bentonite slurry shall be photographed.
- 2.3.7 Permeameter Testing. Permeameter testing will be conducted in accordance with the Army Corps of Engineers Manual EM 1110-2-1906 using back pressure saturation and downflow conditions. Flexible wall permeameters shall be loaded with each of the backfill mixtures and leached with RMA tap water until one porewater volume has passed through the backfill mixtures. of three permeameter tests shall be run on each backfill mixture. One of the three tests for each backfill mixture will serve as a control test. Control cells will be leached with only RMA tap water throughout the duration of the test, and will consist of the selected mix with the percent bentonite which produced a permeability near 1 x 10EE-7 cm/sec during optimization testing. The remaining two permeameters for each backfill mixture shall be leached with the contaminated ground-water, after one pore volume of RMA tap water has passed. At least two pore volumes of contaminated ground-water will be leached through the backfill mixtures. One of these permeameters will contain the same mix and percent bentonite as the control cell. The other permeameter will contain the same mix as the control cell with a higher bentonite content that produced a permeability close to 1 x 10EE-8 cm/sec during optimization testing. The samples will be compressed into the cell manually in order to reduce the amount of entrapped air.
- 2.3.7.1 Elevated hydraulic gradients shall be used in order to complete permeameter testing within a reasonable period of time (minimum two months). A pressurized nitrogen source will be used to achieve the required hydraulic gradients. The hydraulic gradient to be applied is 28. The confining pressure to be applied is 5 psi.
- 2.3.7.2 The permeameter influent will be tested for TOC, specific conductivity, bromide, pH, alkalinity, sodium, calcium, chloride, VOA (Volatile Organics), and BNA (Base Neutral Acid Extractible Organics) immediately prior to permeameter testing. Effluent from the permeameters will be collected and tested for the same chemical constituents after each porewater volume has passed through the sample. This data will be used to estimate the amount of contaminant adsorption/desorption taking place.
- 2.3.7.3 As the permeameters are opened after completion of the tests, a visual examination of the samples will be performed. The purpose of the visual examination is to determine whether months of testing has altered the general appearance of the sample. Observations similar to those made in

the pre-test examination (color, texture) will be recorded and the samples will be photographed.

2.3.8 Selection of Backfill Mixture. Results of the compatibility study will be used to select the backfill mixture (constituents and proportions) to be used during construction. Selection will be based on:

Permeability (lowest)
Backfill soil alteration (lowest)
Difference in permeability between tap water and contaminated ground-water (lowest)
Field constructibility and quality control (greatest)
Cost (lowest)

The MRD Lab will issue a report on the compatibility study, including all data sheets and calculations. The Final Design Analysis will reference this report and contain a discussion of the results, including the mixture selection.

- 2.4 Field Vs. Laboratory Permeability. For groundwater modelling purposes, a permeability of 1 x 10EE-7 cm/sec was assumed for the in situ slurry wall backfill. Using that permeability, a wall thickness of 3 feet, and a head differential of 3 feet across the wall, the calculated time for water to flow through the wall is 20.5 years (see calculation sheets, Appendix A). However, Darcy's Law takes into account advection of water only, while diffusion and dispersion of contaminants generally causes them migrate faster than water. At very low permeabilities, some studies have shown diffusion and dispersion predominate over advection as a means of contaminant transport. Research has been done to quantify diffusion and dispersion for individual contaminants, but the effects of multiple contaminants is largely unknown. During the life of the wall, water levels inside and outside the cell will be monitored to assure a negative head into the wall. An extraction trench near the north boundary will be used as necessary to maintain a negative head. The designers have decided not to specify a laboratory permeability an order of magnitude lower than the anticipated field permeability. With proper specification and field quality control (i.e., mix design, frequency of QA/QC testing, full mixing) the field permeability should not be severely compromised. If unexpected water flows into the cell, the extraction system will be utilized to remove it.
- 2.5 Control of Negative Head within Isolation Cell. Removal of ground water trapped within the isolation cell will be required in order to maintain a lower ground-water level within the cell than that outside the cell. This lower level within the cell will assure that no contaminated ground water will migrate out of the isolation cell. Additionally, ground-water recharge into the cell through the cutoff walls and floor of the cell must be considered. The ground-water level drop across the cell is 13 feet, from elevation 5250 at the south to elevation 5237 at the north. Once the cutoff walls are completed, ground water that is trapped within the cell will begin to seek equilibrium. If an equalized horizontal ground-water level were allowed to occur, this level would be at elevation 5244. The equalization process will automatically effect a negative head (a ground-water level within the cell below that outside the cell) from the south cutoff wall northward for a distance of about 250 feet. Since the soil within the cell (and without) has a low hydraulic conductivity,

ground-water flow toward the north cutoff wall will be very slow. Estimated time to reach equilibrium at elevation 5244 without ground-water withdrawal is 16.3 years (the finite difference ground-water model predicts 16 years). graphical flow net (see discussion section 2.7, Elevation of Ground-Water Flow Diversion) indicates a slight rise in the ground-water level at the south cutoff wall, from elevation 5250 to about 5255, and a slight drop at the north cutoff wall from elevation 5237 to about 5236. Again, as in the equalization process within the cell, the rise and drop of ground-water levels will occur over many years. Because of this, calculations made for the control of the negative head within the isolation cell are based on an initial ground-water elevation of 5250 at the south cutoff wall and elevation 5237 at the north cutoff wall. Initial design ground-water elevations for the negative head are 5243 near the center of the cell and 5234 at the north cutoff wall. Final designed ground-water level is 5234 across the entire cell. Ground-water extraction is normally accomplished In this case, however, production wells are impractical. hydraulic conductivity, impermeable boundary effects, and well interference Analyses were conditions are factors that make well extraction impractical. The results indicate that maximum made for ground-water removal by wells. production from each well would be considerably less than 1.0 gallons per minute (gpm), about 0.08 gpm. Ground-water removal can be accomplished by a single, horizontal drain located 100 feet south of the north cutoff wall. This location of the drain is dictated by the necessity of lowering the ground-water level in the northern one-half of the isolation cell (the southern one-half will automatically adjust to a negative head). The drain is located slightly closer to the north cutoff wall to provide drawdown to elevation 5234 (about 3 feet) whereas the drawdown near the center of the cell must be at elevation 5243 (about Soil conditions at this location favor the emplacement of the drain at elevation 5227. Ground-water flow to the drain was calculated by quantitative methods outlined by Freeze and Cherry (1979). This method involves prediction of ground-water inflow to a vertical excavated face. The model is partially bounded by impermeable boundaries. The equations for this model are time dependent. The drain does not exactly conform to the model, i.e. vertical open face vs enclosed buried drain and impermeable boundaries at the ends of the drain. Given these conditions, estimated maximum ground-water production during the first 230 days of operation is about 19 gpm. This would result in an average drawdown of about 3.5 feet within the isolation cell. Only a minimal volume of ground-water withdrawal is required to maintain a negative head within the cell. The volume of trapped ground water within the cell above elevation 5234 (the designed ground-water level at the north cutoff wall) is 1,111,600 cubic feet. A withdrawal rate of 5 gpm for 230 days and 2.2 gpm for 396 days will lower the ground-water level to the designed elevation of 5234 at the north wall only in about 1.7 years. Since it will require about 11 years to reach elevation 5236.5 outside the cell, lowering the ground-water level in 1.7 years results in a safety factor of 6.4. Ground-water flow into the isolation cell through the cutoff walls and the floor of the cell will be negligible. The rate of flow is calculated to be about 40 cubic feet per day, about 0.2 gpm. The volume of ground water occurring between elevations 5234 and 5235 is 82,225 cubic feet. The time required to raise the ground-water level from elevation 5234 to elevation 5235 due to recharge through the cutoff walls and floor will be about  $5 \frac{1}{2}$  years.

- Drain Construction. A 6-inch diameter slotted pipe drain shall be installed in a 3-foot wide trench excavated from ground surface to elevation 5228 at the east end of the drain and to elevation 5226 at the west end of the drain. The pipe drain will lead to a lift station located on the west end of the trench. Centralizers will be placed on the drain pipe to assure centering of the pipe within the trench. Fine aggregate for concrete will be used for filter sand. One foot of filter sand shall be placed in the bottom of the trench for bedding for the drain pipe. The filter sand shall be placed around and above the drain pipe to the elevation of the water table, 5239, in 3-foot lifts. Gradation of the filter sand is in accordance with EM 1110-2-1901, Seepage Analysis and Control for Drains. Random backfill shall be placed from the water table to the ground surface. A biodegradable slurry shall be used for the full depth of excavated trench to prevent sloughing of the sidewalls. The biodegradable slurry shall be clean (desanded or new) prior to the placement of the perforated drain pipe. Slurry and biodegraded slurry removed from the trench shall be considered contaminated and shall not be allowed to leave the isolation cell area and will be spread out over the surface. Design of the filter sand is included in Appendix A.
- 2.7 Evaluation of Ground-water Flow Diversion. Graphical representations of flow through porous media are called flow nets. Flow nets are an invaluable aid in the solution of various ground-water flow problems. Flow nets are a collection or set of flow lines intersecting a set of equipotential lines. An unlimited number of flow lines and equipotential lines may be drawn, but only a few may be selected to accurately illustrate the general flow condition for The construction of flow nets involves many intuitive the immediate problem. deductions and may be considered an art rather than a science. However, if fixed conditions are the rule at all points of a boundary of a saturated soil mass, a flow net is uniquely determined. That is to say, one and only one solution If, however, there is a change in boundary conditions, a new unique solution will then exist, but it may take a long interval of time to achieve steady state conditions. One flow new and one ground-water flow diagram were constructed to determine the possibility of diversion of contaminated ground water into non-contaminated or less contaminated areas. The flow net and groundwater flow diagram are included in Appendix A. The only information a priori for the flow net were ground-water levels measured in 1989. A pre-construction flow diagram was constructed for comparison with a post-construction flow net. Although a uniform saturated thickness was assumed for the construction of the flow net, the error introduced will only have minimal effect on the study. The resultant upgradient and downgradient potentials from the post-construction flow net were estimated based on the configuration of a priori equipotential contours. The study indicates that there will be a rise in ground-water level at the south wall of the slurry trench (upgradient) of about five to six feet (elev. 5255 to 5256). Conversely there will be a drop in ground-water level at the north wall of the slurry trench (downgradient) of about one foot (elev. 5236). The finite difference ground-water flow model predicts a rise only to elevation 5252.5 south of the isolation cell, and a drop to elevation 5237 north of the cell. lines of the net indicate that ground-water flow will be diverted about equally east and west of the containment cell. The ground-water flow will parallel the sides of the containment cell and then will converge north of the containment cell, again nearly following the flow path that the ground-water regime had prior

to the construction of the containment cell. It is concluded that there will be no significant diversion of the ground-water flow regime.

- 2.7.1 Ground-water Flow Model. A finite difference ground water flow model was used to simulate ground water flow in the alluvial aquifer of the lime settling basin area at Rocky Mountain Arsenal. Software used to develop the model is part of the Well Field Simulation Package developed by Hall Groundwater Consultants. The model is based on a finite difference computer model developed by Prickett and Lonnquist (1971) which has been modified by Hall Groundwater to run on IBM PC compatible computers.
- 2.7.1.1 The data base used to develop the model was drawn from a bedrock elevation map and a groundwater elevation map prepared by Woodward and Clyde Consultants. Data required for the finite difference grid nodes were extrapolated from these two maps. Permeability of 2.12 gallons/day/foot<sup>2</sup> (1x10<sup>-4</sup> cm/sec) was used for the model. This value was confirmed by a series of slug tests recently conducted by Woodward and Clyde Consultants. The storativity used for the model was 0.2. Modeling was conducted in three phases. Two finite difference grids were used. The first two phases of modeling were based on a symmetrical, 29x29 grid. Grid spacing varied between 200 feet, at the outer margins, to 50 feet within the area of the lime settling basin. The third phase of modeling used a 29x26 grid with a constant node spacing of 25 feet. Model configurations are included in appendix A.
- 2.7.1.2 Initial modeling used only data input from the groundwater elevation and bedrock elevation maps in order to calibrate the model. Boundary conditions were varied during this phase of modeling to most closely approach the current groundwater conditions at the Lime Settling Basin. The closest approximation to actual conditions at the Lime Settling Basin Site was achieved by setting up all of the boundaries as constant head boundaries. In the Hall Groundwater Model a constant head boundary is modeled by using an extremely high storativity value in the nodes which define the boundary. A value of  $2 \times 10^{12}$  was used for this modeling.
- The model was calibrated by simulating existing head conditions in the unconfined aquifer. Results of the calibrations are included in appendix A. After the model was calibrated, the slurry wall was input into the model by reducing the permeability at the nodes which define the position of the wall by three orders of magnitude relative to background. A value of .00212 gallons/day/foot<sup>2</sup> (1x10<sup>-7</sup> cm/sec) was used for the slurry wall permeability. Boundary conditions were the same as in the first phase of model runs. These model runs were used to determine the effects of the slurry wall on the local groundwater flow system and to compare the computer generated flow system with a flow net which was generated, based on hand calculations, prior to the start of computer modeling. The match between the computer generated flow system and the flow net matched over most of the model. There were slight differences between the two flow systems near the northern boundary of the slurry wall because of a minor difference in extrapolated groundwater head contours used in developing the two models. The results of the modeling of the flow overall flow regime within and surrounding the isolation cell are included in appendix The computer simulation indicates a slight rise in ground-water level upgradient of the isolation cell (about 2.5) feet, and a slight drop downgradient

(about 2 feet). The ground-water is shown as equalizing within the isolation cell at about elevation 5245. Total time to attain stabilized ground-water flow after construction of the isolation cell is about 11 1/4 years.

- 2.7.1.4 The third phase of modeling was concerned only with flow within the confines of the slurry wall. Model boundaries were determined by the position of the slurry wall over much of the model, where the boundary was set as a no flow boundary. In the northern part of the model boundaries were set up as constant head boundaries. While a constant head boundary in this location is not realistic, the relative impermeability of the slurry wall makes the effects of a constant head boundary negligible, considering it was only with the interior of the slurry wall area that this phase of modeling was concerned. Results of the modeling indicate that the groundwater will stabilize within the isolation cell at about elevation 5243 in about 19 1/2 years. This model simulation does not consider any ground-water removal from the isolation cell. Results of the modeling are included in appendix A.
- 2.7.1.5 A row of pumping wells was input within the slurry wall area 100 feet south of the north slurry wall to try to simulate the effects of a drain. Ten wells were simulated and at all pumping rates ground-water withdrawal was so rapid the wells were considered to be pumped dry by the model. The model run of a pumping rate of 0.10 gpm resulted in a drawdown to about elevation 5235.5 at the north wall of the isolation cell. The pumping dry of the well is a result of a combination of boundary effects and the low permeability of the material that makes up the aquifer. The results of the computer modeling of ground-water withdrawal are included in appendix A.
- 2.8 Evaluation of Bedrock Aquifer Contamination. A piezometer cluster is located 50 feet east of the east wall of the isolation cell at coordinates N 2,185,002; E 181,126. This cluster has separate piezometers installed in the alluvium and the Denver "A" sandstone unit which is 34.5 feet below the top of bedrock. Ground-water elevation in alluvium was measured at elevation 5248 and ground-water elevation in the Denver "A" sandstone unit was measured at elevation 5254. These measurements were made in April 1990. The measurements indicate there is a downward hydraulic gradient into the Denver formation of 0.032 ft/ft. The designed elevation of ground-water within the isolation cell to maintain negative head is 5234. This will result in an upward gradient from the Denver "A" sandstone unit into the isolation cell of 0.26 ft/ft. Since the gradient is upward into the cell, there will be no contamination of the Denver Formation from the isolation cell. Ground-water flow from the Denver Formation into the isolation cell is calculated to be about 25 cubic feet per day. Calculations concerning bedrock contaminations are included in appendix A.
- 2.9 Alignment of Slurry Wall. It was observed during site visits and reviews of current aerial photography and 1940's topographic maps, that the extent of sludges deposited outside the Lime Settling Basins could be possibly up to 10 feet in depth. Information from the investigative borings confirm that sludges deposited north of the Lime Settling Basins are approximately 7 to 9.5 feet in depth, approximately 1 to 2 feet in depth on the area west of the basins, and 1 to 2 feet in depth on the south side area of the basins. The option to place the slurry wall around the existing Lime Settling Basins only, did not provide enough storage capacity to contain all the excavated contaminated sludges

outside the Lime Settling Basins. It was felt that the deposited sludges outside the existing Lime Settling Basins should also be contained within the slurry wall isolation cell, as they could be considered a contaminant source. The alignment of the Slurry wall around the Lime Basins was extended to the north in order to contain more contaminated in-situ sludge material, and provide for more storage capacity of excavated contaminated soils. The area contained by the slurry wall isolation cell is directly adjacent to Basin A, and therefore the slurry wall will be constructed through contaminated soils. The slurry wall will not completely surround the contaminated area, but it will contain the contaminated source area of the Lime Settling Basins.

2.10 Slurry Trench Width and Depth. The width of the slurry trench will The depth of the slurry trench was estimated to have a maximum depth of 35 feet from the ground surface and an average depth of 28 feet. The trench will be keyed into the Denver Formation claystone 2 feet. Establishment and maintenance of a negative head within the isolation cell will only require that the bottom of the trench be excavated through the overburden material. Emplacement of the slurry wall through the overburden will eliminate excessive recharge into the isolation cell. Only slight leakage, if any will occur through the claystone and into the cell when the slurry wall is keyed two feet below the top of bedrock. Whenever uncemented, loose fine-grained sandstone is encountered at the top of bedrock, it will be excavated to the depth of cemented, hard finegrained sandstone or claystone whichever is encountered first. The cemented sandstone has a low permeability,  $1.0~\mathrm{x}~10^{-5}~\mathrm{cm/sec}$  or less, and will not appreciably affect the recharge into the isolation cell. Average depth of excavation into the Denver Formation is anticipated to be just slightly greater than two feet.

#### 2.11 Construction.

- 2.11.1 Work Zones. The exclusion, contaminant reduction, support, and staging zones are shown in the drawings. The support zone is located west of the Lime Basins, north of the RMA Fire Station. The staging and contaminant reduction areas are located just east of the support zone. Arsenal personnel do not want heavy dump trucks loaded with off-site borrow soil to access the site via December 7 Avenue because the trucks might damage the pavement. Therefore a gravel access road will be built accessing the site from the east. To keep that road clean, empty trucks will exit the site via the southwest.
- 2.11.2 Grading. Minor grading will be necessary to provide a construction platform for the slurry wall installation. The work platform will be 40 feet wide and have a maximum slope of 1% along the slurry wall centerline. Since the existing surface soils are contaminated, the work platform will be covered with 12" of clean borrow material in order to provide a clean area on which to work.
- 2.11.3 Excavation. Excavation of the trench will be made with a large track mounted extended-reach backhoe or by a crane-mounted slurry-trench clamshell. The trench is kept from collapsing by the bentonite slurry. Water for slurry mixing operations is available from the water truck filling facility at the RMA Fire Station. Excavated materials will be placed in the isolation cell, if it is determined during compatibility testing that the material is

unsuitable for backfill. The Contractor will have the option of performing the overexcavation of contaminated materials on the south, north, and west of the Lime Basins either before or after construction of the slurry trench.

- Sequential Construction Evaluation. sequential construction of the slurry trench has been made to determine if a significant lowering of the ground-water table will occur during the construction of the isolation cell. Once the south cutoff wall has been constructed, groundwater lowering will occur on the north side (eventually in the trapped portion of ground water within the cell). The greatest lowering (or escape out of the cell) of ground water as a result of sequential will occur if excavation is started at the north end of the east cutoff wall. The excavation must then proceed southward for excavation of the east wall thence continuing around the isolation cell until completion of the cell is made by connecting to the north end of the east wall. It is calculated that 5,310 cubic feet of ground water will escape the isolation cell because of this sequential construction. amount is insignificant when compared to the amount that must be removed (about 1,111,600 cubic feet) for maintenance of a negative head. Since sequential construction will place a restriction on the contractor's operations, which is not cost justified, sequential construction of the slurry wall will not be Calculations concerning sequential construction are included in specified. appendix A.
- 2.11.5 Slurry Preparation. The Contractor will choose the method of mixing slurry. It is anticipated slurry will be mixed by a bulldozer on a concrete pad or by a high velocity mixer. The method, design, and rationale for the slurry mixing operation will be a Category I submittal.
- 2.11.6 Stability. The stability of a 28-feet deep (average) slurry trench is not anticipated to be a major concern, since trenches over 100 feet deep have been successfully completed by others.
- 2.11.7 Backfilling. Backfill material will be blended and trucked to the trench where it will be moved into the trench with a bulldozer. Blending operations are typically done with a pug mill operation or by mixing with a bulldozer on a concrete mixing pad. The Contractor will select the method of blending the backfill material. Blending operations will be done in the Contractor's staging area. The method, design, and rationale for the chosen mixing method will be a Category I submittal.
- 2.11.7.1 Backfill Rate. The Corps guide spec states the toe of the slope of the trench excavation shall not precede the toe of the backfill slope by less than 50 feet or more than 105 feet (although those values may be changed). Xanthakos states there is no real reason for specifying somewhat arbitrary distances, and says that the minimum distance would be the distance the Contractor would need to properly clean the bottom of the trench, which he states is approximately 30 feet. EPA-540/2-84-001 recommends the distance be minimized for stability reasons, but states it may be up to 200 feet. D'Appolonia recommends having slurry in the trench for at least 24 hours prior to placing backfill to allow for proper filter cake formation. None of the references checked listed any method or reason for specifying a maximum distance between the toe of the excavation slope and the toe of the backfill slope.

Therefore the specification states that the distance will be kept to the minimum value which will allow both cleaning of the trench bottom and a minimum 24 hours between slurry placement and soil-bentonite backfill placement. Because a formal stability study was not undertaken, it will also be specified that the distance shall not be greater than 105 feet without the approval of the Contracting Officer.

- 2.11.8 Bends in Alignment. The slurry trench will be overexcavated at corners to assure the full depth of the trench for at least 2 feet outside the isolation cell.
- Compacted Clay Trench Cover. To prevent the soil-bentonite backfill mixture from desicating, the top one foot (cut out of the work platform) will be covered with compacted clay obtained from the previously mentioned clay borrow area used during Basin F remediation. The cover will be 8 feet wide and will be placed between 2 and 4 days after backfilling. At this time it may only be compacted with a backhoe bucket or small hand-operated smooth drum roller because the soil-bentonite backfill may still be somewhat soft. Two weeks after backfilling, the cover will be recompacted with standard compaction equipment and any areas of settlement will be filled in with more clay material and compacted. At this time the Contractor will excavate two areas of the trench to be used as heavy equipment crossings during subsequent construction. crossings consist of 2 18-inch and one 12-inch layer of compacted clay separated by geotextiles as shown on the plans. The crossing design is similar to that used on the Kane and Lombard Superfund Site. During construction of the vegetative cover, the compacted clay wall cover and the work platform will be covered by random fill, topsoiled, and vegetated.
- 2.11.10 Quality Assurance/Quality Control. The Quality Control program for this project is similar to that of the Helen Kramer Landfill site. QA/QC testing of materials is given in Tables 1 and 2 of specification section 02214, Soil-Bentonite Slurry Trench Cutoff. These tables are given in Appendix A. In addition, soundings to determine the top of bedrock, trench bottom, and backfill slope will be made at horizontal intervals of 20 feet. Undisturbed samples of the completed trench for permeability testing will be taken every 400 lineal feet.
- Abandonment of Existing Wells and Piezometers. Wells and 2.11.11 piezometers 36055A, 36055B, 36058, 36059, 36076, 36167, and 36194 in the Lime Settling Basins area and 01503 and 01504 in the M-1 Basins area will be The abandonment is required because the wells and piezometers are abandoned. located in the construction area. The abandonments will be accomplished prior to other construction activities. Abandonment will be in accordance with RMA Concrete pads will be broken and removed; surface protective, steel casings will be pulled and removed; and the remaining PVC casings and screens will be overdrilled with a hollow stem auger. A cement-bentonite grout mixture of 94 pounds of Type II Portland cement, 3 pounds of powdered bentonite and a maximum 8 gallons of water. The grout will be placed in the overdrilled hole by tremie pipe beginning at the bottom and continuing to the ground surface while the auger sections are removed. A complete record of original well installation data and well abandonment procedures and data will be made for each abandoned well and piezometer.

- 2.12 LONG TERM MONITORING. Long term monitoring for ground-water quality and piezometric levels will be required to assure the isolation cell is performing as designed. This will be made possible by installation of monitoring wells and piezometers. Monitoring wells will be placed upgradient, and downgradient of the isolation cell and crossgradient on each side of the isolation cell. These wells will be placed near the center of the alignment of the east, south, west, and north walls of the isolation cell. One monitor well will also be placed inside the isolation cell near the center of the north wall. Piezometers will also be placed near the centers of the alignments of the walls and will be located very close to the walls. The piezometers will be inside and outside (mirror imaged) the isolation cell to closely monitor for the maintenance of the negative head within the cell. The locations of monitor wells and piezometers are shown in the Contract drawings.
- 2.12.1 Construction and Installation of Monitor Wells and Piezometers. Construction and installation of monitoring wells and piezometers will follow procedures outlined in MRD Policy Letter #90-001. The construction will consist of installation of 4-inch ID (for monitor wells) and 2-inch ID (for piezometers) PVC, threaded casings and continuous wire wound type screens; end caps; no grease of oils (other than vegetable oils) will be allowed. Designed sand filter packs, bentonite seals and cement-bentonite grout will be required. Well and piezometer development will be required and turbidity of the water will be measured after development has been completed. Design of the filter sand is included in appendix A. Diagrams of the monitor wells and piezometers are shown in the Contract drawings.

#### 3. VEGETATIVE COVER (LIME SETTLING BASINS).

- 3.1 Design. The cover to be constructed is intended to be a vegetative cover over the Lime Settling Basins. This cover will minimize infiltration and promote drainage away from the Lime Settling Basins. The substantive standards contained in 40 CFR 264.310, specifically those requirements contained in subsections a(2)-(4), and b(1) and (4), describe the necessary standards relevant to this cover. The cover will consist of 12" of compacted fill material and topped with 6" of topsoil. The cover will have a minimum slope of 2 percent to promote drainage. The cover will be seeded with an appropriate seed mixture to minimize erosion to less than 2 tons/acre/year. The Hydrologic Evaluation of Landfill Performance (HELP) Model has been used to determine rainfall infiltration rates through the vegetative cover. Infiltration rates are currently estimated to be less than 0.012 inches/year. A summary of the HELP Model Analysis is located in Appendix A.
- 3.2 Pond Dewatering and Filling. The Lime Settling Basins will have approximately 2 acre-feet of water removed prior to fill material placement. Pending the results of the water quality testing, the water will be drained into the drainage located to the northeast of the Lime Settling Basins, which eventually flows into Basin A. Impacts of the additional water to Basin A will be evaluated. Other options include the construction of a lined evaporative pond which could be used to store the water until evaporated. The evaporative pond would be lined with a geomembrane to prevent infiltration into the ground. Once

drained, the Lime Settling Basins will be filled with clean fill material up to the existing ground water elevation of approximately 5248.

3.3 Contaminated Excavations. Contaminated soils outside the slurry wall containment cell, located to the south, west and north, will be excavated and placed inside the containment cell. Newly placed contaminated soils will be placed above ground-water level. Dust control will be critical during all excavations.

#### 4. SHEET PILE CUTOFF WALL (M-1 SETTLING BASINS)

- 4.1 Criteria. The Decision Document requires the containment system consist of a 360 degree subsurface barrier around the M-1 Settling Basins, vitrification of soil/sludge by introducing an electric current through an array of electrodes, an offgas treatment system for capture of organics, air monitoring during implementation, and ground-water monitoring to evaluate the continued effectiveness of this ISV alternative. Steel sheet piling was determined to be the preferred barrier to be installed. Sheet piling will allow quick, easy installation, and provide temporary containment of the ground-water during the ISV process. The sheet piles will be removed after vitrification.
- 4.2 Location and Alignment. Information supplied by Geosafe Corporation, the ISV vendor (Application and Evaluation Considerations for In Situ Vitrification Technology: A Treatment Process for Destruction and/or Permanent Immobilization of Hazardous Materials, April 1989), a very steep thermal gradient, approximately 150-200 degrees C per inch, precedes the advancing melt surfaces. Typically, the 100 degrees C isotherm is less than 1 foot away from the molten mass. It was decided to locate the sheet pile 10 feet away from the design limits of vitrification in order to provide adequate room for ISV operations.
- 4.3 Key Depth. The sheet piles will be driven one foot into the bedrock surface, or until refusal. The boring logs along the sheetpile alignment show bedrock at a depth of 9 to 14.5 feet, generally 9 feet on the south boundary increasing to 14.5 feet on the north boundary.
- 4.4 Compatibility With Contaminated Groundwater. The sheet piling is a temporary measure to reduce the flow of groundwater into the area prior to and during vitrification primarily to save electricity (and therefore money) by reducing the amount of water that is evaporated during vitrification. The Rocky Mountain Arsenal Project Manager (PMRMA) has indicated the time between sheet pile placement and vitrification will be on the order of a few months. For this reason, compatibility of the steel with the contaminated groundwater is not considered to be a problem and no compatibility testing will be done.
- 4.5 Pile Sizing. The pressures against the pile and bending moment of the pile are not anticipated to be major concerns, since no excavation will take place inside the cell. The vitrification process does result in a volume decrease and therefore subsidence of the ground surface, but experience at other vitrification projects has shown this to be only a few feet. Since the vitrified mass will be several feet from the sheet piling, the full amount of subsidence will not take place against the sheetpiling but several feet away from it. After

vitrification the subsided area will be filled in with clean soil to avoid leaving a depression in the area. Therefore the major consideration in pile sizing is to survive the driving process. Piles used for the cutoff wall will be PZ22 steel sheetpile.

#### 4.6 Construction.

#### 4.6.1 Sheet Pile Installation.

- 4.6.1.1 Work Zones. The work zones for construction are shown on the drawings. The Exclusion Zone extends 10 feet outside the sheet pile wall centerline. The Contractor will store his equipment and perform all operations from the inside the area to be surrounded by the sheet pile. The Arsenal does not want workers straying outside the exclusion zone since that area is also contaminated. A note has been placed on the drawings stating that workers are not to go outside of the work zones.
- 4.6.1.2 Vibrations. There is concern vibrations produced during pile driving may damage adjacent structures. Of major concern to the Arsenal is an underground rigid asbestos water line located just south of December 7 Avenue (about 50 feet north of the northern pile boundary). experience in the field of soil dynamics has shown that peak particle velocity is the parameter most closely related to vibratory damage of structures. As long as peak particle velocity is less than 1 or 2 inches per second damage will not One inch per second is about the lowest vibration most people can perceive. Vibratory hammers produce much less vibration than impact hammers, Figure 7 of and this job will be specified as vibratory hammer only. "Construction Vibrations: State-of-the-Art" (ASCE Journal of the Geotechnical Engineering Division, February 1981) shows that at a distance of 50 feet, the peak particle velocity produced by a vibratory hammer will be approximately 0.3 The project plan calls for demolition of above ground inches per second. structures inside the sheet piling and up to 10 feet outside the sheet piling. According to Figure 7, at a distance of 10 feet a vibratory hammer will produce a peak particle velocity of about 2 inches per second. It is possible structures between 10 and 25 feet away from the driving might receive some damage. However, these structures are not in use now and most probably never will be used again. Any damage that might occur would be minor concrete cracking, as the peak particle velocities are not high enough to cause adjacent structures to collapse. Therefore, it is not anticipated vibrations will be a problem beyond 10 feet. As a precaution, four settlement monuments will be installed in the area prior to driving. Two will be located near the previously mentioned water line about 50 feet north of the north side of the sheetpile, one will be located near the overhead pipe just north of tank T 66, and one will be located just north of the concrete structure 561. The latter two monuments will be approximately 15 feet from the east and south boundaries of the sheetpile respectively. monuments shall be monitored daily for the first several days of driving and when driving is occurring close to the monuments. If settlement is observed, the Contractor may have to adjust his operations. After the sheet piles are driven and in place, the piles will be cut off to be flush with the existing ground.
- 4.6.2 Sheet Pile Removal. The sheet piles will not be removed under this contract, but will be removed by others in the future.

- 4.6.3 Abandonment of Existing Wells and Piezometers. Abandonment of existing wells and piezometers in the construction area will be in accordance with RMA Standard Operating Procedures and/or MRD Policy Letter #90-001.
- 4.7 LONG TERM MONITORING. Long term monitoring of the M-1 Basins will be done by others and is not required in this contract.
- 5. CIVIL: GRADING, PAVING, AND DRAINAGE. (LIME SETTLING BASINS)
- 5.1 DESIGN REFERENCES. The following references were used in preparing the grading, paving, and drainage design:
  - 5.1.1 Department of the Army and Air Force Technical Manuals.

TM 5-820-1 88-5, Chap 1	Surface Drainage Facilities for Airfields and Heliports (Aug 87)
TM 5-820-4 88-5, Chap 4	Drainage for Areas Other Than Airfields (Oct 83)
TM 5-822-2 88-7, Chap 5	General Provisions and Geometric Design for Roads, Streets, Walks, and Open Storage Areas (July 87)
TM 5-822-5 88-7, Chap 3	Flexible Pavements for Roads, Streets, Walks, and Open Storage Areas (Oct 80)

5.1.2 Department of the Army Technical Manuals (TM).

5-820-3 Drainage and Erosion Control, Structures for Airfields and Heliports (Jan 78)

5.1.3 Engineer Manuals (EM).

1110-2-2902 Conduits, Culverts and Pipes (Mar 69)

5.1.4 NEENAH Foundry Company Publication.

Inlet Grate Capacities for Ponded Water

5.1.5 Engineering Technical Letter (ETL)

1110-1-140 Pavement Design for Roads, Streets, and Open Storage Areas (July 88)

- 5.2 GRADING. The following criteria was used to develop site grading.
  - 5.2.1 Crown grade of 2 percent.
  - 5.2.2 Maximum desirable ramp grade of 7 percent. Absolute maximum ramp grade of 10 percent for short distances only.
  - 5.2.3 Minimum grade of 1 percent for overlot grading for cohesionless sandy soils and 2 percent for cohesive soils or turfed areas.
  - 5.2.4 Minimum ditch grade of 0.3 percent.
  - 5.2.5 Maximum foreslopes of 1V on 4H and backslopes of 1V on 3H.
- 5.3 FLEXIBLE PAVEMENT. The temporary construction access road was designed for a drivable surface for construction equipment and for dust control.
  - 5.3.1 Traffic consists of the following vehicles:
- 1) various construction equipment including dump trucks and earth moving equipment.
  - 5.3.2 Strength Method. (Non-Frost Design)

Class = E
Category = IV
Design Index = 4
CBR = 7
Design Thickness = 12 inches

- 5.3.3 Recommended Pavement Section.
  - 6-inches Crushed Rock Surface Course
  - 6-inches Crushed Aggregate Base Course
  - 6-inches Compacted Subgrade (95% maximum density)
- 5.4 DRAINAGE. Drainage was designed in accordance with AFM 88-5, chapter 1, TM 5-820-3, and TM 5-820-4. The existing storm drainage system was extended and routed around the lime settling basin. The 30-inch diameter Reinforced Concrete Pipe (RCP) was partially removed, to clear the slurry trench, capped, and abandoned in place. This 30-inch RCP was previously abandoned and capped upstream and carried no storm discharge. The 24-inch RCP was removed to the last down stream manhole and extended from this location. Due to the small drainage area added to this drain line no increase in pipe size was required.
- 5.4.1 Storm Drain Pipe. Storm drains were designed to withstand earth dead loads as well as H-20 or HS-20 highway live loads.
- 5.4.1.1 Pipe Materials. Reinforced Concrete Pipe (RCP) was chosen to match the existing storm drainage system.

5.4.1.2 Pipe Joints. Watertight pipe joints were required to prevent infiltration of soils through the joints due to the presence of ground water at or above the pipelines and the use of erodible backfill materials.

#### 5.4.2 Inlet Capacity.

5.4.2.1 Area Inlets. The capacity of area inlets in a sump condition was determined using the nomograph in the NEENAH Foundry Company publication entitled "Inlet Grate Capacities for Ponded Water" for a NEENAH type R-6118 catch basin frame and grate.

#### 6. WATER SUPPLY AND WASTEWATER COLLECTION. (LIME SETTLING BASINS)

- 6.1 DESIGN REFERENCES. The following references were used in preparing the water supply and wastewater disposal design:
  - 6.1.1 Department of the Army Technical Manuals (TM).

TM 5-814-1 Sanitary and Industrial Wastewater Collection-Gravity Sewers and Appurtenances (Mar 85)

TM 5-814-2 Sanitary and Industrial Wastewater Collection-Pumping Stations and Force Mains (Mar 85)

- 6.1.2 National Standard Plumbing Code (1983).
- 6.1.3 Recommended Standards for Sewage Works by the Great
  Lakes-Upper Mississippi River
  Board of State Sanitary
  Engineers (1978 Edition).
- 6.2 GENERAL. The work under this project consists of containing and pumping contaminated water from within the perimeter of the slurry wall at the Lime Settling Basins. It was determined that the ground-water should be artificially depressed within the confines of the slurry wall in order to prevent the migration of contaminated ground-water away from the project boundary.
- 6.2.1 The Containment and Pumping system consists of a 36-inch diameter lift station, 1 HP sump pump and 660 feet of 2-inch forcemain. The system is designed to contain the estimated flow rate of 5 gpm from the perforated groundwater collection drain and pump it to the CERCIA Water Treatment Plant. The volume to be pumped is considered a finite amount, necessary to provide a negative head/gradient within the settling basins.
- 6.2.2. Constructibility was the most significant consideration in the design. The collection drain is to be placed approximately 25 deep in heavily contaminated, water saturated, sandy clays which are not stable enough for normal trench excavation. Therefore, the piping will installed by a slurry method. A standard concrete type lift station would be very difficult to construct in the material at the depths required. Therefore, a 36-inch diameter polyethylene

pipe will be used for the pump chamber because it can be attached to the collection piping above ground and easily lowered into the trench through the slurry.

- The 36-inch diameter pump chamber is 33 feet deep and is designed to provide 5 feet of storage volume between the invert of the collection drain and the bottom of the pump chamber. The 5 feet of depth amounts to 265 At a inflow rate of 5 gpm, the storage volume will take gallons of storage. approximately 50 minutes to fill allowing the pump adequate time to cool. The design requires a 1 HP sump pump to operate at 22 gpm at 52 feet of head. With the storage volume available the pump will operate for approximately 12 minutes during each pump cycle. The pump is controlled by three float switches suspended in the lift station. The lowest float switch is the pump "off" control, the second float switch located at the elevation of the collection pipe invert is the pump "on" control and the highest float switch located 1 foot above the These switches will invert of the collection pipe is the "alarm" switch. automatically control the pump operation. However, a manual lift station switch will be provided at the CERCLA Water Treatment Plant to shutdown or turn on the In addition, any alarms at the lift station will be lift station controls. monitored at the CERCLA Water Treatment Plant. The manual control and alarm monitoring will be part of the CERCLA Water Treatment Plant project, however, provisions have been made in this design to accommodate this work.
- 6.2.4. Approximately 1000 feet of 2-inch forcemain is needed to convey the contaminated water from the lift station to the CERCLA Water Treatment Plant. However, only 660 feet of 2-inch forcemain will be provided under this project because not enough survey is available for entire length of the pipe and the exact location for the CERCLA Plant has not been finalized. The remainder of the piping to the CERCLA Plant will be provided as part of the CERCLA Plant project. The route of the forcemain will be easily identified by new overhead power lines, required to power the lift station, running immediately parallel to the forcemain and the end of the forcemain will be identified with a marking post.
- **6.2.5.** The lift station is designed to facilitate all maintenance without entering the pump chamber. Discharge piping is connected directly to the pump and runs directly up to a union at the top of the manhole which can be disconnected to raise pump and piping from the pump chamber during maintenance activities.
- 6.3 M-1 BASIN DESIGN. Also incorporated within this design package is the relocation of a fire hydrant and capping of various utilities near the M-1 Basins on the south side of December 7th Avenue to facilitate operability of the ISV process (to be designed/constructed in FY 90 thru 93).
- 7. CHEMISTRY. No chemical analysis is required by the Contractor other than outlined in the Site Safety and Health Plan (SSHP).

#### 8. ELECTRICAL (LIME SETTLING BASINS)

**8.1** General. The electrical design is based on the following codes, standards, publications, etc:

- 8.1.1 National Electrical Code (NEC) NFPA No. 70-1990
- 8.1.2 Life Safety Code NFPA No. 101-1990
- 8.1.3 National Electrical Safety Code (NESC) ANSI C2-1990
- 8.1.4 Architect Engineer Instruction Manual AEIM 14(Rev. July 1990)
- 8.2 Scope. This design will provide electrical power for the ground water waste pump located at the lime settling basins.
- 8.2.1 The new basin M-1 cutoff sheet pile walls will be located near existing 13800V 3-phase lines on both the north and west side of the cutoff wall. These lines will be either removed or relocated by the Rocky Mountain Arsenal's electrical distribution contractor.
- 8.2.2 A new aerial extension of the existing 13800V 1-phase line will be installed from the existing line west of "D" Street and routed to the west edge of the lime settling basins" cap.
- 8.2.3 A single phase pole mounted transformer would be provided at the end of the new aerial extension. The transformer will have fused cutoff switch and surge arresters. The transformer secondary will be 240/120V and will be routed above the cap in plastic conduit with an equipment ground. The conductor will be sized for load and distance from transformer to load (voltage drop considerations). A combination circuit breaker type motor starter with weather proof enclosure will be locate near the pump.
- 8.2.4 A ground fault circuit interrupter 120V, 20 ampere receptacle will be located on or near the combination motor starter.
- 8.3 Specifications. The following guide specifications will be edited for this project: (See Attachments)

Note that section CEGS-16415-OD would be retitled Electrical Work. In addition, section CEGS-16401-OD will be provided.

- 9. Health and Safety. The specifications for the remedial action will present requirements to ensure that the Contractor performs the work in compliance with applicable regulations, especially 29 CFR 1910.120, "Hazardous Waste Operations and Emergency Response". The specifications will require the Contractor to maintain a Safety and Health Program and to prepare a Site Safety and Health Plan (SSHP) covering all work to be performed under the construction contract. The paragraphs below describe background information and decision logic involved in determining specific requirements that will be included in the specifications.
  - 9.1 Site description and contamination characterization.
- 9.1.1 Site description. (General) RMA occupies more than 17,000 acres (approximately 27 square miles) in Adams County, directly northeast of

metropolitan Denver, Colorado. The property was purchased by the US government in 1942 for use in World War II to manufacture and assemble chemical warfare materials, such as mustard and lewisite, and incendiary munitions. Starting in the 1950s, RMA produced the nerve agent GB (isopropyl methylphosphonofluoridate) until late 1969. A significant amount of chemical warfare materials destruction took place during the 1950s and 1960. From 1970 to the early 1980's, RMA has primarily been involved with the destruction of chemical warfare materials. In addition to these military activities, major portions of the plant facilities were leased to private industries, including Shell Oil Company, between 1947 and 1982, for the manufacture of various insecticides and herbicides.

- 9.1.1.1 M-1 Settling Basins Description: The M-1 Settling Basins are located in the South Plants area, just south of December 7th Avenue along the northern edge of the northwest quarter of Section 1. The basins and the berms surrounding them, all of which are now buried and partially built upon, occupy an area of approximately 34,500 square feet.
- 9.1.1.1.1 The M-1 Settling Basins were constructed to treat waste fluids from the lewisite facility. Two basins were constructed in 1942, and a third basin was constructed in 1943 when the original two filled with solids. All three were unlined, and each measured approximately 90 feet wide, 115 feet long, and 7 feet deep. In addition to the waste fluids from the lewisite disposal facility, the basins may have contained lesser amounts of waste materials from alleged spills within the acetylene generation building, the thionylchloride plant, and the arsenic trichloride plant, which may have been routed through floor drains and the connecting piping to the basins. The basins also received a considerable amount of mercuric chloride catalyst, possibly from a spill.
- 9.1.1.1.2 The liquids discharged into the basins first passed through a set of reactor towers where calcium carbonate was added, then through a wood trough into the M-l settling basins where the arsenic precipitated out of solution. The elutrate was decanted through an 18-inch diameter pipe to the Lime Settling basins in Section 36 where final treatment occurred, prior to being routed to Basin A.
- 9.1.1.1.3 The M-1 Settling basins were backfilled, probably in 1947, and are now covered with soil. Portions of the basins are covered with structures. The facilities that surround the M-1 Settling Basins area were used in the manufacture of bicycloheptadiene until 1974.
- 9.1.1.2 Lime Settling Basins Description: The Lime Settling Basins, located in Site 36-4, are in the southwestern portion of Section 36 at RMA and consist of three unlined basins, each approximately 1 acre. The boundaries of the Lime Settling Basins include berms that surround the basins as well as associated materials that separated the basins. The total area of investigation is approximately 210,000 square feet and has an average surface elevation of 5,255 feet above mean sea level (MSL).
- 9.1.1.2.1 The Lime Settling basins were constructed in the early 1940's to remove arsenic from South Plants wastewater by precipitation. Wastewater was treated with lime at the site to precipitate metals and reduce

arsenic concentrations generated by the manufacture, and later the demilitarization, of lewisite. The basins were also constructed to receive wastewater from the industrial activities at the South Plants until the chemical sewer was constructed in the early 1950s. All wastewater originating from the South Plants area was channeled through the Lime Settling Basins prior to entering Basin A. This water flowed through an underground sewer and into a ditch along the south side of the basins. From the ditch, flow into the basins was controlled. Materials possibly contained within the basins include a reported spill of 500 gallons of mercury catalyst and the disposal of approximately 150 drums of mustard in the basins between 1959 and 1960. Reports also note that the mustard may have been neutralized, and that the term "drum" refers to a volume and not that the material was disposed of in drums.

- 9.1.2 Contamination characterization. Previous field sampling has shown contamination to be present in soil, ground-water and surface water at the Lime and M-1 Settling Basins. Classes of chemicals detected include organochlorine pesticides, organosulfur compounds, volatile organic compounds, metals, and agent degradation products. Additional field work is currently underway to further characterize the contamination at these sites. Soil and water samples are being collected and analyzed for volatiles, semi-volatiles with DBCP, organochlorine pesticides, thiodiglycol, ICP metals, arsenic and mercury. A detailed list of chemical names, concentration ranges and media in which found will be included after the latest analytical results are received.
- 9.2 Hazard Assessment and Risk Analysis. The remedial action for the Lime and M-1 Settling Basins will involve a number of tasks/operations. The following is a preliminary list of general tasks/operations. A more detailed description will be available later in the design process.

Mobilization and Site preparation
Demolition of structures
Abandonment, installation of monitoring wells
Construction of slurry walls
Installation of drain/trench system
Excavation of sludge from outside wall
Construction of clay "cap" (cover).
Construction of sheet pile cutoff wall
Seeding
Demobilization and site closeout

The following is a list of general hazards that may be encountered. As the tasks are further defined, detailed hazard analyses will be conducted for each task.

Physical Hazards

Normal outdoor work hazards: slips, trips, falls, etc.

Normal construction hazards:

Moving equipment Use of power tools trenching hazards falling objects

Noise

Heat/cold stress (depending on the time of year)

Biological Hazards

Poisonous and/or thorny vegetation Insect bites, stings Snakes Diseases carried and transmitted by rodents

Chemical Hazards

volatile halogenated solvents
volatile aromatic solvents
mustard agent-related organic compounds
herbicide-related organosulfur compounds
GB agent-related organic compounds
organochlorine pesticides and pesticide-related compounds
metals

- 9.3 Accident Prevention. The contractor will be required to follow accident prevention procedures outlined in the USACE Safety Requirements Manual (EM 385-1-1). Some of these requirements (i.e. training, hazard analysis, ...) are addressed in other sections of this Design Analysis. The SSHP prepared by the Construction Contractor will serve as the Accident Prevention Plan (APP) and Activity Hazard Analyses (phase plans) described in EM 385-1-1, thus a separate APP will not be required. Accident reporting requirements will also be addressed.
- 9.4 Staff organization, qualification, and responsibilities. The contractor will be required to develop an organizational structure that sets forth lines of authority, responsibility, and communication. Part of this organization will be personnel responsible for oversight and implementation of the health and safety aspects of this program. Since this site remedial action is being undertaken pursuant to CERCLA, the requirements of 29 CFR 1910.120 apply. Therefore, to ensure a "qualified" person is responsible for health and safety, the contractor will be required to utilize the services of an Industrial Hygienist certified in Comprehensive Practice by the American Board of Industrial Hygiene. The CIH will be required to:
- posses a minimum of 3 years experience in developing and implementing health and safety programs at hazardous waste sites or in the chemical industry,
- have demonstrable experience in supervising professional and technician level personnel, and
- have demonstrable experience in developing worker exposure assessment programs and ambient air monitoring programs.

The CIH will have the primary responsibility for implementation, oversight, and enforcement of the health and safety aspects of this remedial action. It will not be necessary for the CIH to be on-site for the entire duration of field work. A fully trained and experienced Site Safety and health Officer (SSHO), responsible to the Contractor and the CIH, may be delegated to implement and continually enforce the safety and health program and site-specific plan elements on-site. The SSHO will be required to posses:

- a minimum of 1 year experience in developing and implementing health and safety programs at hazardous waste sites or in the chemical industry,

- demonstrated experience in construction safety techniques and procedures.

- a working knowledge of Federal and state health and safety regulations,

- specific training in personal and respiratory protective equipment program implementation and in the proper use of air monitoring instruments, air sampling methods, and procedures.

Each crew actively working in the contaminated areas will be required to include a fully trained and experienced Safety and Health Technician to perform monitoring and ensure compliance with the approved SSHP.

The Contractor will be required to have at least one person certified in first air/CPR by the Red Cross, or equivalent agency, on-site during all site operations.

- 9.5 Training. All employees working on-site with the potential for exposure to hazardous substances, health hazards, or safety hazards shall meet the minimum training requirements—as specified in 29 CFR 1910.120. These employees will have completed the 40 hour hazardous waste training requirements and have three days of field experience in hazardous waste work. All supervisory personnel will have an additional 8 hours of training as specified for management of personnel and activities associated with hazardous waste site activities. Documentation of this training will be required for all personnel; in addition documentation pertinent to annual refresher courses as required in 29 CFR 1910.120 will also be required. All employees will be required to attend site-specific training covering site hazards, procedures, and all contents of the approved SSHP prior to entering the site.
- Because of the nature of this 9.6 Personal protective equipment (PPE). work, it is likely that engineering controls and work practices will not provide sufficient control of the hazards, therefore, the contractor will be required to provide personal protective equipment to all affected employees. This PPE shall provide dermal and respiratory protection specific to the site hazards. Selection of appropriate PPE will be based on air monitoring results (for respiratory protection) and an evaluation of the potential for dermal exposure during each task (for dermal protection). The Contractor will be required to establish a written personal protective equipment program in compliance with 29 CFR 1910.120(g)(5). Basic levels of protection will be similar to those listed Historical information and past field activities in the Lime and M-1 Settling Basins have indicated the possible presence of chemical agents and their Therefore, the level of PPE required during intrusive breakdown products. activities shall be Level B.

- 9.6.1 Level D Protection:
  - Hard hat
  - Safety glasses with side shields or safety goggles.
  - Work clothing as prescribed by weather.
  - Steel toe work boots.
  - Hearing protection (if needed)
- 9.6.2 Modified Level D Protection (all elements of Level D above plus:)
  - disposable outer coveralls (tyvek or equivalent)
  - disposable boot covers.
  - Surgical inner gloves.
  - Chemically protective outer gloves (as per PPE program).
  - 9.6.3 Level C Protection:
    - Hard hat
    - Work clothing as prescribed by weather.
    - Disposable outer coveralls (saranex coated tyvek or

equivalent)

- Disposable boot covers
- Steel toe work boots.
- Hearing protection (if needed)
- Surgical inner gloves.
- Chemically protective outer gloves (as per PPE program).
- Air purifying respirator (APR) with appropriate cartridges (selected as per respiratory protection program).

#### 9.6.4 Level B Protection:

all elements of Level C except air supplied respirators will be substituted for air purifying respirators.

- 9.7 Medical Surveillance. The contractor will be required to institute a medical surveillance program meeting the minimum requirements established by 29 CFR 1910.120. In order to ensure adequate medical surveillance for the hazards at this site, the contractor will be required utilize the services of a licensed physician who is certified in Occupational Medicine by the American Board of Preventative Medicine, or who, by necessary training and experience, is Board-eligible. The Contractor will be required to provide the physician with a copy of the employees' job descriptions, the SSHP, 29 CFR 1910.120, and Section 5.0 of NIOSH publication 85-115.
- 9.8 Exposure monitoring/air sampling program (personal and environmental). Because of the potential for airborne contamination, the contractor will be required to conduct air monitoring/sampling in order to establish proper levels of respiratory protection. Background conditions will be established prior to the start of work. As a minimum, real-time air monitoring for organic vapors and dust will be necessary within all work areas of an intrusive nature. Monitoring for chemical agents and arsine may also be required. This monitoring will continue throughout the duration of the activity.
- 9.8.1 In addition to the real-time monitoring, the contractor will be responsible for ensuring compliance with all requirements of 29 CFR 1910.120(h).

- 9.9 Standard operating safety procedures, engineering controls and work practices. All pertinent procedures will be addressed and implemented as described in the Contractor's SSHP.
- 9.10 Site control measures. Because contamination exists at this site, the Contractor will be required to establish work zones and site control measures to prevent the spread of contamination.
- 9.11 Personal hygiene and decontamination. Whenever employees are potentially exposed to contamination, they will be required to undergo decontamination procedures. The contractor will be required to set forth appropriate decon procedures for each level of protective clothing worn onsite. A personnel decon facility with shower facilities will be required. Details about the disposal of trash, contaminated disposable PPE and decon water will be included in the specifications.
- 9.12 Equipment decontamination facilities and procedures. The Contractor will be required to decontaminate all equipment that has come into contact with contamination. The Contractor will be required to establish an equipment decon pad in the CRZ.
- 9.13 Emergency equipment and first aid requirements. The Contractor will be required to have the following items immediately available for on-site use:
- 9.13.1 First aid equipment and supplies approved by the consulting physician.
- 9.13.2 Emergency eyewashes/showers meeting the standards of ANSI Z-358.1
  - 9.13.3 Emergency respirators (worst-case appropriate).
  - 9.13.4 Spill control materials and equipment.
  - 9.13.5 Fire extinguishers.
- 9.14 Emergency response plan and contingency procedures (on-site and off-site). The Contractor will be required to prepare an Emergency Response Plan in compliance with 29 CFR 1910.120(1), which addresses the following elements, as a minimum:
- 9.14.1 Pre-emergency planning and procedures for reporting incidents to appropriate government agencies for potential chemical exposures, personal injuries, firs/explosions, environmental spills and releases.
  - 9.14.2 Personnel roles, lines of authority, communications.
- 9.14.3 Posted instructions and a list of emergency contacts (physician, nearby medical facility, fire and police departments, ambulance service, federal/state/local environmental agencies, CIH, Contracting Officer).

- 9.14.4 Emergency recognition and prevention.
- 9.14.5 Site topography, layout, and prevailing weather conditions.
- 9.14.6 Criteria and procedures for site evacuation (emergency alerting procedures/employee alarm system, emergency PPE and equipment, safe distances, places of refuge, evacuation routes, site security and control).
- 9.14.7 Specific procedures for decontamination and medical treatment of injured personnel.
  - 9.14.8 Route maps to nearest pre-notified medical facility.
- 9.14.9 Criteria for initiating community alert program, contacts, and responsibilities.
- 9.14.10 Procedures for critique of emergency responses and followup. The Contractor will also be required to ensure all emergency response procedures set forth by RMA are followed.
- 9.15 Heat/cold stress monitoring. Ambient weather conditions will dictate when heat and cold stress monitoring requirements are appropriate. Ambient temperature readings and the type of clothing worn will affect the type and extent of monitoring required. The contractor will be required to provide and implement protocols for heat and/or cold stress monitoring.
- 9.16 Sanitation. The Contractor will be required to provide, in the Support Zone, potable water and washing facilities consisting of hot and cold running water, towels and soap for men and women as necessary. (See also paragraph 6.11: Personal hygiene and decontamination.) At least 1 toilet, and if there are more than 20 employees, at least 1 toilet seat and 1 urinal per 40 workers will be required. A sanitary break and lunch area will be required in the Support Zone.
- 9.17 Logs, reports, and recordkeeping. Proper documentation will be an important part of the remedial action. The contractor will be required to keep the following records:
- 9.17.1 OSHA Records. Required OSHA records are listed in Table 61.
- 9.17.2 Daily log and safety inspection reports. The daily log and safety inspection report shall include practices and events that affect safety and health, safety and health discrepancies encountered and safety and health issues brought to the supervisor's attention. Each entry shall include:
  - 9.17.2.1 Date
  - 9.17.2.2 Work area
  - 9.17.2.3 Employees present in work area
  - 9.17.2.4 PPE and work equipment being used in each area.

- 9.17.2.5 Special health and safety issues and notes
- 9.17.2.6 Signature of preparer.

## APPENDIX A

#### GEOTECHNICAL

A-1	Bedrock Contour Map
A-2	Sludge Test Information
A-3	Groundwater Flow Diagram
A-4	MRD Lab Test Request
A-5	Bentonite Memo Test From GEO-CON
A-6	Lab Classification Data
A-7	Flow Rate Calculations
A-8	Control of Negative Head Calculations
A-9	Sand Filter Design
A-10	Groundwater Flow Net
A-11	Groundwater Model Configuration
A-12	Groundwater Model Calibrations
A-13	Modeling Results
A-14	Modeling Results - Third Phase
A-15	Groundwater Withdrawal
A-16	Bedrock Contamination
A-17	Sequential Construction Calculations
A-18	Quality Assurance / Quality Control Tables
A-19	Filter Sand Design
A-20	HELP Model Results
A-21	Conversation Records
A-22	Boring Logs and Gradation Analysis
A-23	References

	<u>()</u>		
OMAHA DISTRICT	COMPUTATION SHEET		OF ENGINEERS
PROJECT RMA - LSB+M-1		SHEET NO. /	OF /
ITEM Bedrock Contour	Map	BY IMC	DATE 10-12-90
		CHKD. BY	DATE
3 181,000 24 28	21 52 15 21 22 10 35 25 25 30 31	0000'581'7 II 19 18 33 19 5	- - - - - - - - - - - - - - - - - - -
12	2 3 4 5 7 7 1 10 9 8	52	`52 <b>4</b> 5

#### HVORSLEV ANALYSIS

Hvorslev Equation:

$$K = \frac{R^2 \ln (L/R)}{2 L T_o}$$

where:

K = Hydraulic Conductivity

R = Radius of Well Casing and Screen

L = Length of Well Screen

T<sub>o</sub> = Basic Time Lag at Head Ratio = 0.37

LSB-15: Hvorslev Analysis

$$R = 0.17 ft$$

$$L = 5 ft$$

Falling Head Test:

$$T_{\circ} = 9.5$$
 minutes

$$K = \frac{(0.17 \text{ ft})^2 \ln (5 \text{ ft/0.17 ft})}{2 (5 \text{ ft}) (9.5 \text{ min})} = 1.0 \times 10^{-3} \text{ ft/min}$$

Rising Head Test:

$$T_o = 24$$
 minutes

$$K = \frac{0.17 \text{ ft})^2 \ln (5 \text{ ft/0.17 ft})}{2 (5 \text{ ft}) (24 \text{ minutes})} = 4.1 \times 10-4 \text{ ft/min}$$

LSB-34: Hvorslev Analysis

$$R = 0.17 \text{ ft}$$
  
 $L = 10 \text{ ft}$ 

Falling Head Test:  $T_o = 25$  minutes

$$T_0 = 25 \text{ minutes}$$

$$K = \frac{0.17 \ ft)^2 \ln (10 \ ft/0.17 \ ft)}{2(10 \ ft) (25 \ min)} = 2.4 \times 10^{-4} \ ft/min$$

Rising Head Test: 
$$T_o = 11.75$$
 minutes

$$K = \frac{(0.17 \text{ ft})^2 \ln (10 \text{ ft/0.17 ft})'}{2 (10 \text{ ft}) (11.75 \text{ min})} = 5.0 \times 10^{-4} \text{ ft/min}$$

LSB-35: Hvorslev Analysis

$$R = 0.17 \text{ ft}$$
  
 $L = 10 \text{ ft}$ 

Falling Head Test: T<sub>o</sub> = 16.5 minutes

$$\Gamma_o = 16.5 \text{ minutes}$$

$$K = \frac{(0.17 \text{ ft})^2 \ln (10 \text{ ft}/0.17 \text{ ft})}{2 (10 \text{ ft}) (16.5 \text{ min})} = 3.6 \times 10^{-4} \text{ ft/min}$$

Rising Head Test: T<sub>o</sub> = 39 minutes

$$T_o = 39 \text{ minutes}$$

$$K = \frac{(0.17 \ ft)^2 \ \ln \ (10 \ ft/0.17 \ ft)}{2 \ (10 \ ft) \ (39 \ min)} = 1.5 \ x \ 10^{-4} \ ft/min$$

#### **BOUWER AND RICE ANALYSIS**

### Bouwer and Rice Equation:

$$\ln s_o - \ln s_t - \frac{2 K L t}{r_c^2 \ln(r_o/r_w)}$$

where:

 $s_0 = initial$  drawdown in well due to instantaneous removal of water from well

s. = drawdown in well at time t

L = length of well screen

 $r_c = radius of well casing$ 

 $ln(r_e/r_w)$  = empirical "shape factor" determined from tables provided in Bouwer and Rice (1976)

r<sub>e</sub> = equivalent radius over which head loss occurs

r<sub>w</sub> = radius of well (including gravel pack)

H = static height of water in well

b = saturated thickness of aquifer

## LSB-15: Bouwer and Rice Analysis

L = 5 ft

 $r_c = 0.17 \text{ ft}$ 

 $r_{\rm w} = 0.42 \; {\rm ft}$ 

H = 14 ft

b = 14 ft

Falling Head Test:  $s_o = 1.59 \text{ ft}$ 

$$s_0 = 1.59 \text{ ft}$$

 $K = 6.4 \times 10^{-4} \text{ ft/min}$ 

Rising Head Test:  $s_o = 1.64$ 

$$s_0 = 1.64$$

 $K = 3.7 \times 10^4 \text{ ft/min}$ 

## LSB-34: Bouwer and Rice Analysis

L = 10 ft

 $r_0 = 0.17 \text{ ft}$ 

 $r_w = 0.42 \text{ ft}$ 

H = 13.25 ft

13.25 ft

Falling Head Test:  $s_o = 1.76 \text{ ft}$ 

$$s_0 = 1.76 \text{ ft}$$

 $K = 9.6 \times 10^{-5} \text{ ft/min}$ 

Rising Head Test:  $s_o = 0.75$  ft

$$s_0 = 0.75 \text{ ft}$$

 $K = 5.2 \times 10^{-4} \text{ ft/min}$ 

## LSB-35: Bouwer and Rice Analysis

L = 10 ft

 $r_{r} = 0.17 \text{ ft}$ 

 $r_w = 0.42 \text{ ft}$ 

H = 19.65 ft

b = 19.65 ft

Falling Head Test:

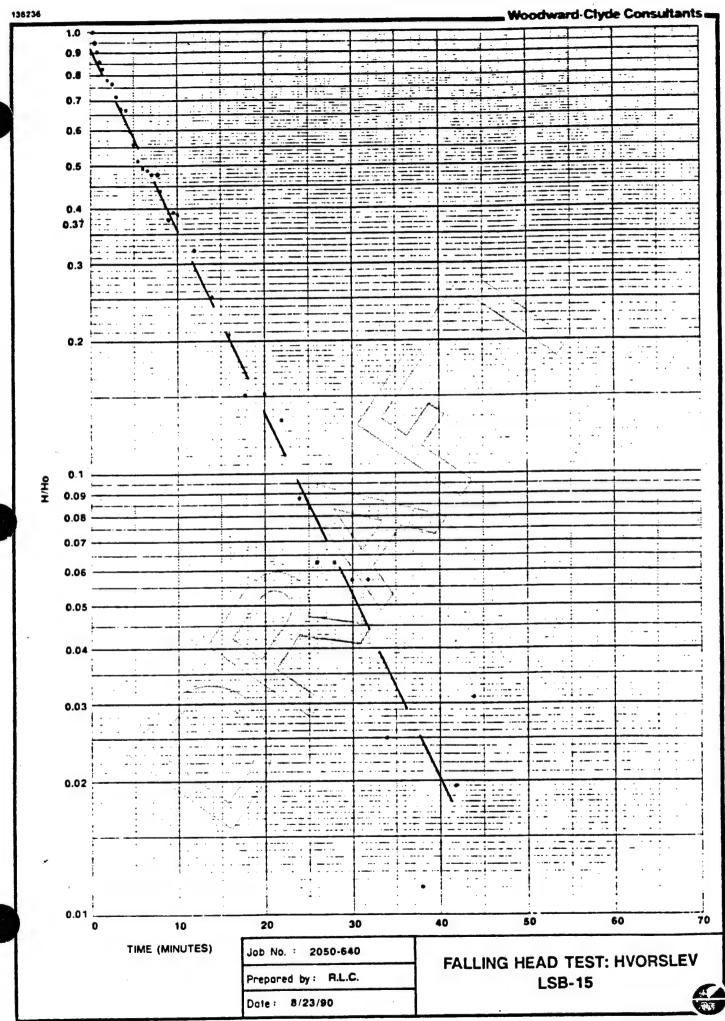
$$s_{\circ} = 1.70 \text{ ft}$$

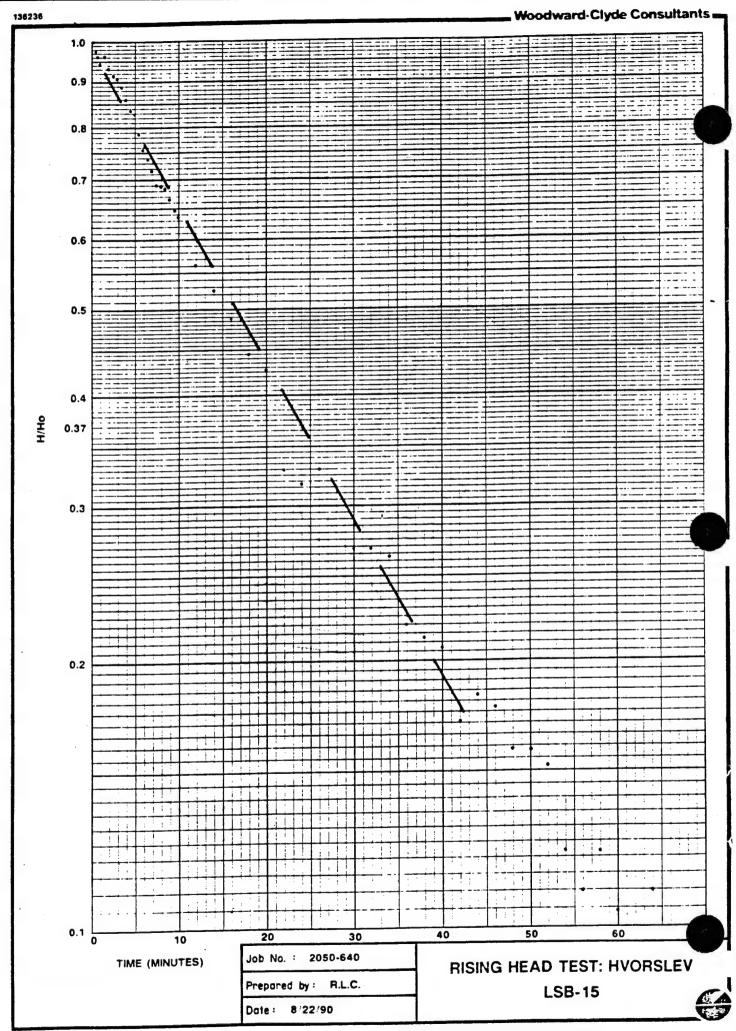
 $K = 3.0 \times 10^{4} \text{ ft/min}$ 

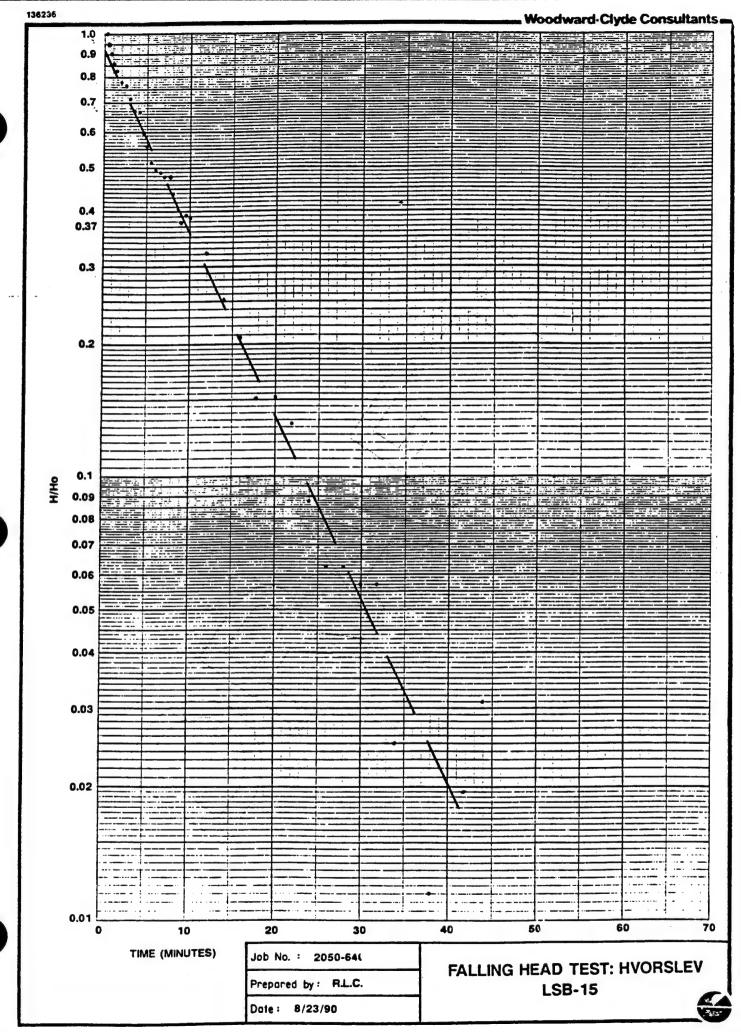
Rising Head Test:  $s_o = 1.58 \text{ ft}$ 

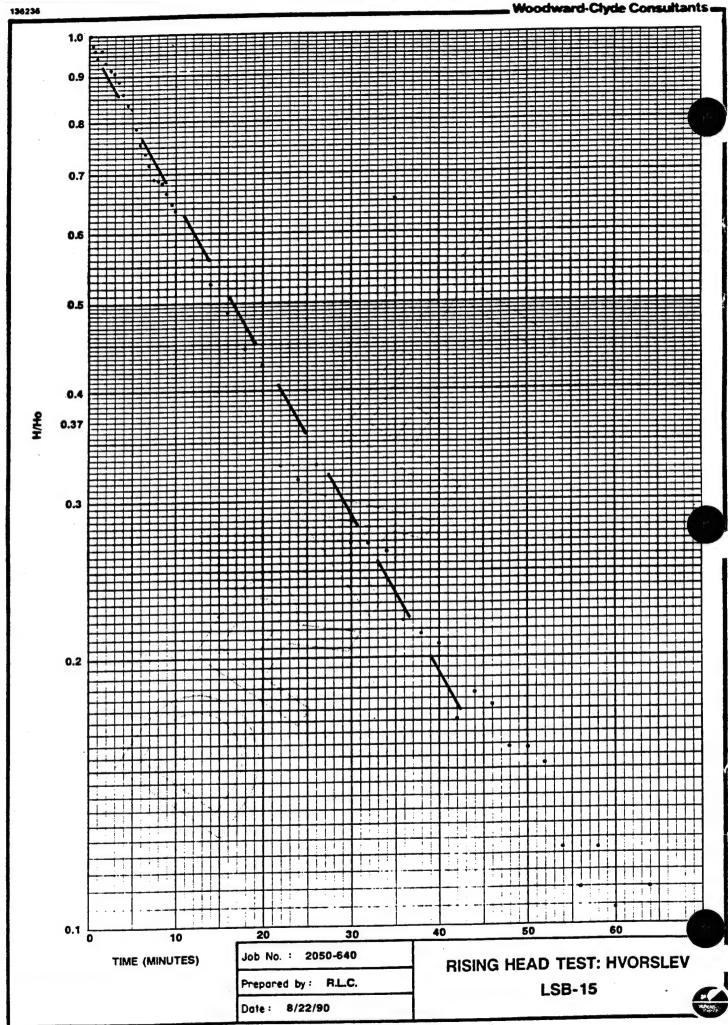
$$s_o = 1.58 \text{ f}$$

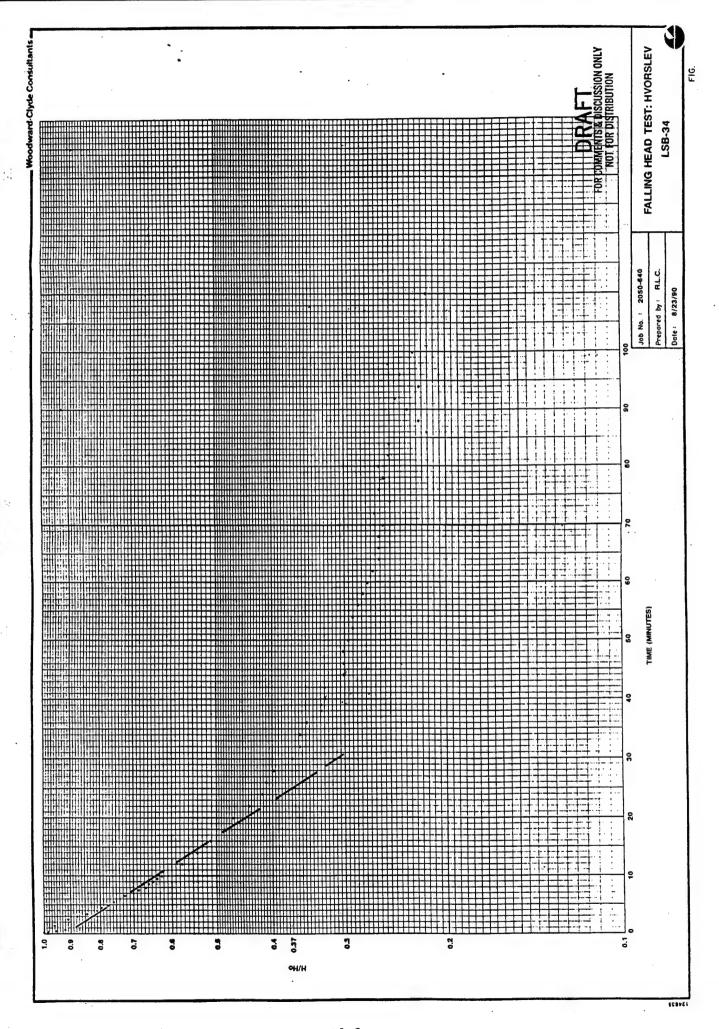
 $K = 1.2 \times 10^{-4} \text{ ft/min}$ 

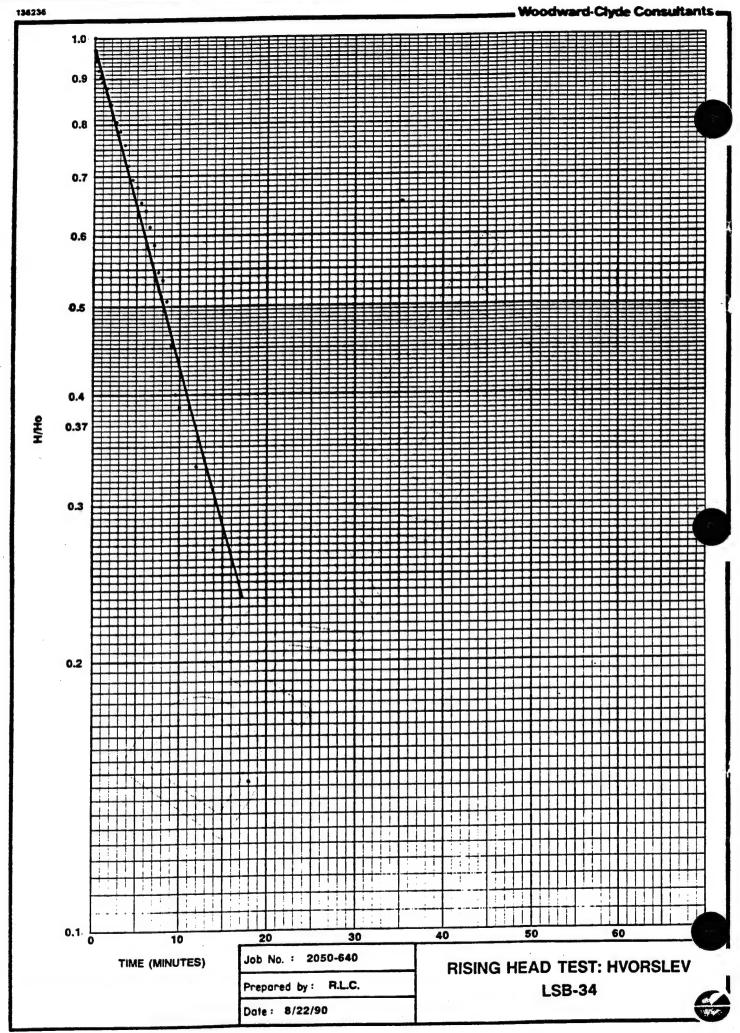


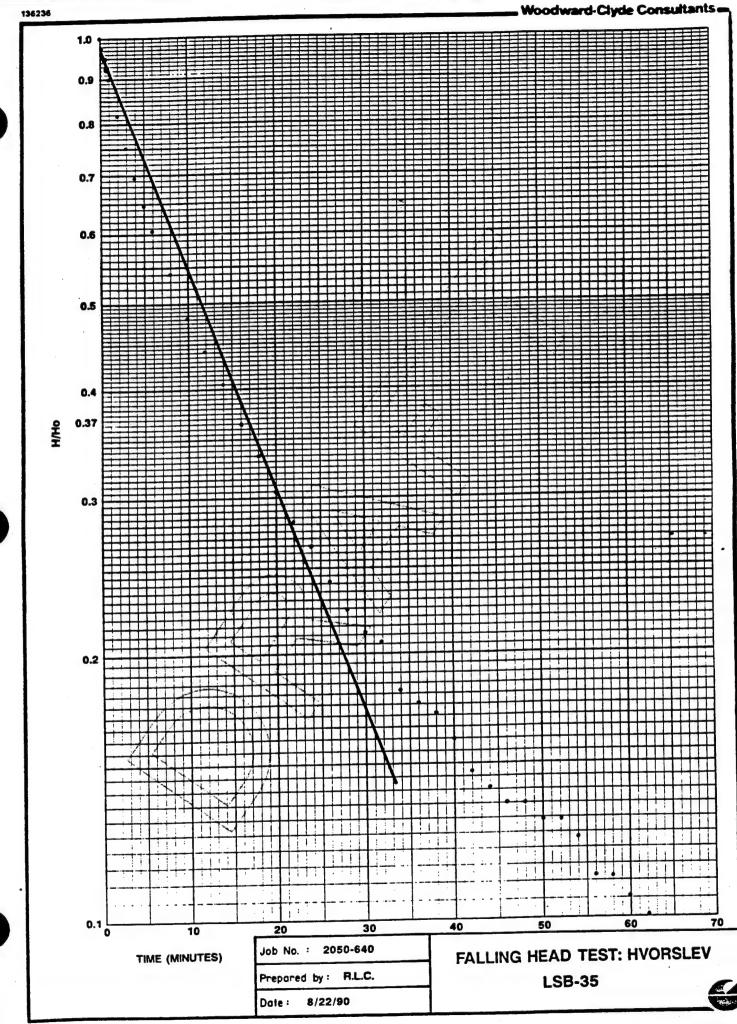


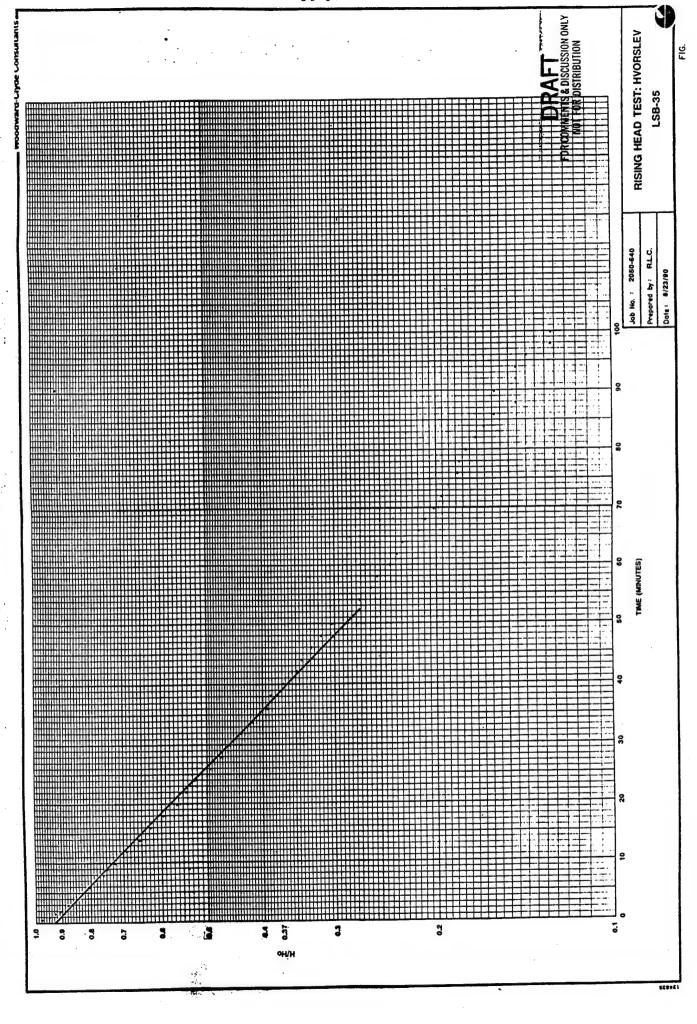


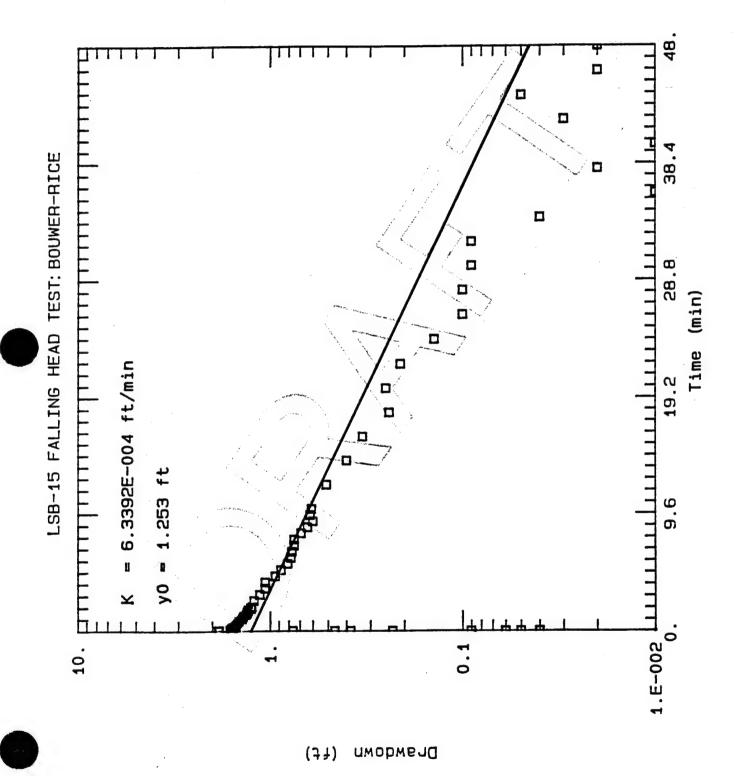




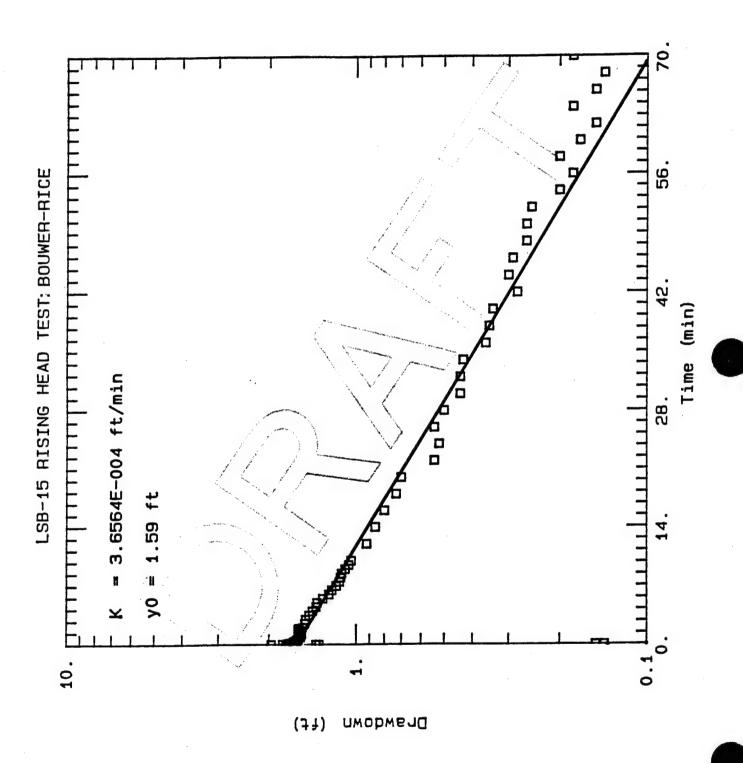


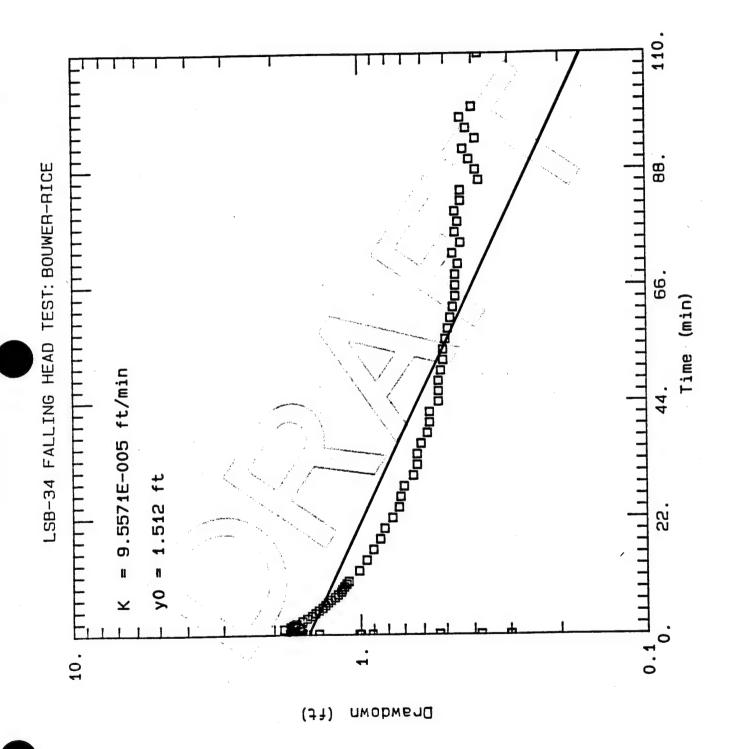


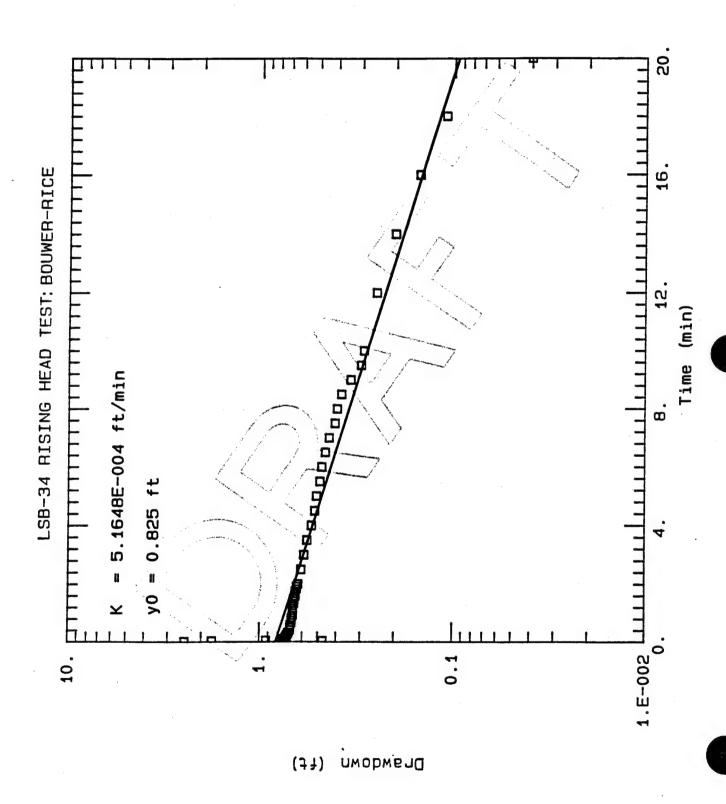


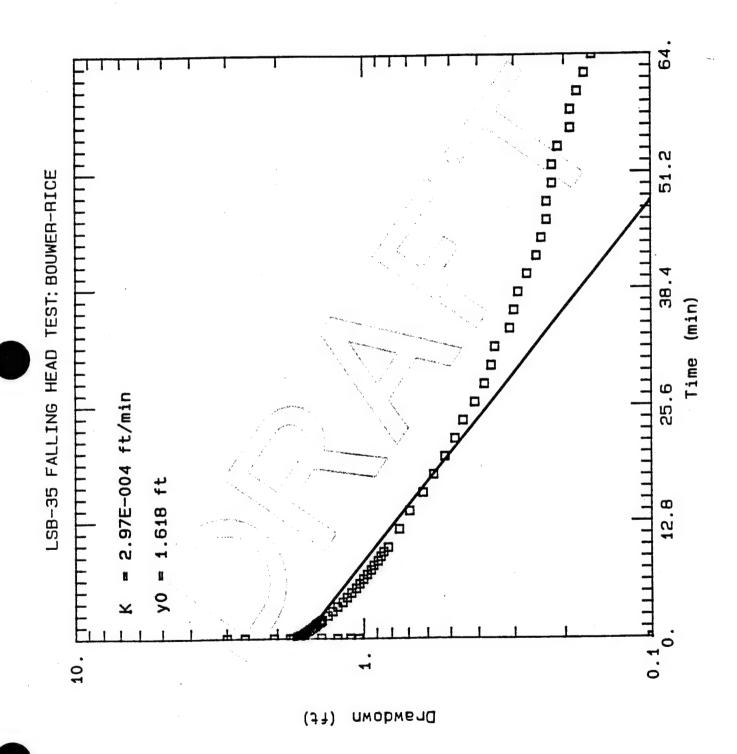


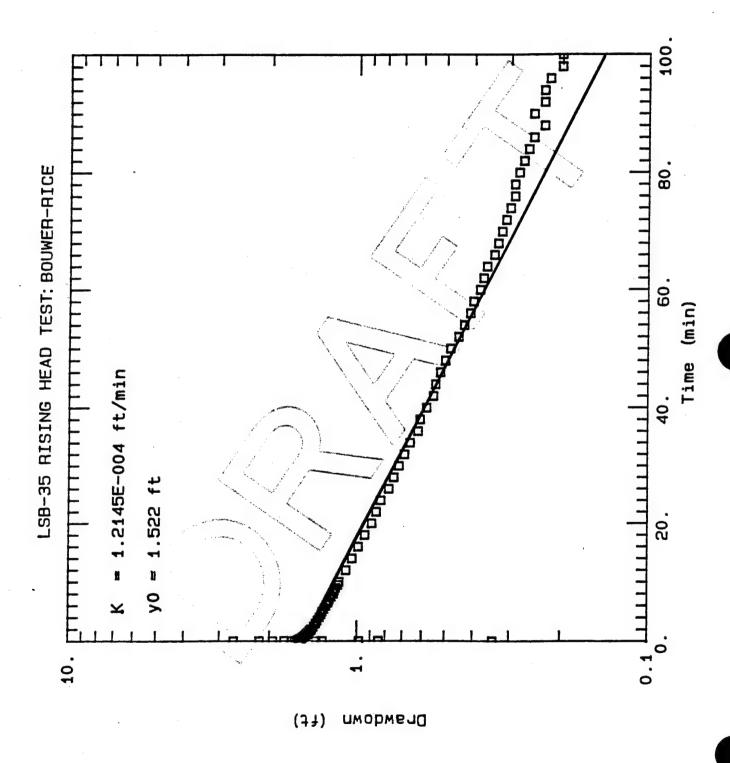
A2-13











## **SLUG TEST DATA FORM**

Location RMA		Name Andre Fledici
Borehole No. LSB-	15	Groundwater Elevation Before Test 11.1 btoc
Test Date 7/23/90		Total Casing Depth 23.2 ft (26.75 btoc)
Measuring Point to	oc	Borehole Diameter 10 in
Type of Test Fallin	g/Rising head	Casing Diameter 4 in
Transductor Probe	Serial No. <u>02813</u>	Screened Interval 18.2 - 23.2
	un No. 1 me and date for on purposes)	Sand Pack Interval 13 - 23.2  Lithology Tested clay, sandy
SF = 10.12 off = 0.002	step 0 Falling head step 1 Rising head	
transducer depth = transducer = 12.01	_	pth (bottom) = 16.5 ft btoc

TABLE 5
SLUG TEST DATA LSB-15

LSB-15

LSB-15

Rising Head Test Falling Head Test Head Change(ft) Head Ratio Head Change(ft) Head Ratio Time(min) Time(min) 0.0033 0.14 -0.09 0.0033 0.15 1.37 0.0066 0.0066 -0.06-0.04 0.0099 1.34 0.0133 0.0133 -0.05 1.96 0.0166 -0.04 0.0166 1.7 1.79 0.02 0.02 -0.060.0233 -0.231.74 -0.38 -0.46 -0.76 0.0266 0.0266 1.74 0.03 0.03 0.0333 0.0333 0.05 1.7 0.05 -1.861.69 1.71 -1.54 0.0666 0.0666 0.0833 -1.83 0.0833 1.71 0.1 -1.5 0.1 1.69 0.1166 -1.62 0.1166 1.65 0.1333 -1.59 0.1333 0.15 1.66 0.15 -1.58 -1.58 -1.57 0.1666 1.66 0.1666 0.1833 1.61 0.1833 1.62 -1.59 -1.58 1.000 0.2 1.000 0.994 0.994 0.975 0.2166 1.64 0.2166 0.994 0.2333 -1.58 -1.55 0.2333 0.994 1.63 0.25 1.62 1.62 0.981 0.987 0.969 0.969 0.2666 0.2833 0.988 0.2666 -1.56 0.988 -1.57 -1.54 -1.54 0.2833 1.000 1.64 - 0.3 0.3 0.3166 1.63 0.994 0.3166 0.3333 -1.55 -1.52 1.62 0.988 0.3333 1.6 0.976 0.4167 0.956 0.976 0.5 1.6 0.5 -1.5 0.943 0.5833 0.976 1.6 -1.48 0.931 -1.47 -1.44 -1.45 0.925 0.6667 0.963 0.6667 1.58 0.963 0.75 0.8333 0.9167 1.55 1.58 0.8333 0.945 0.912 0.887 0.963 -0.9167 -1.411.55 1.54 1.55 1.54 0.945 -1.38 0.868 -1.39 -1.37 -1.37 -1.33 1.0833 1.0833 1.1667 0.874 0.945 0.862 1.1667 0.862 1.25 1.25 1.53 1.57 1.58 1.3333 0.933 1.3333 0.957 1.4166 -1.320.830 1.4166 -1.31 -1.31 -1.29 0.963 0.824 1.5 1.5833 1.5 0.951 0.945 0.957 1.56 1.55 1.5833 1.6667 1.75 0.811 1.6667 -1.3 -1.25 -1.26 0.818 0.786 0.792 1.57 1.75 1.58 1.57 1.8333 0.963 1.8333 0.957 1.9167 1.9167 1.53 2.5 0.780 0.761 0.711 0.933 -1.24 -1.21 0.915 2.5 1.49 1.45 0.909 -1.13 3 3.5 0.667 -1.06 1.41 1.37 0.667 0.860 -1.060.591 4.5 0.835 -0.941.36 1.3 1.24 1.21 1.17 0.829 0.793 0.756 0.553 5.5 -0.88 0.509 -0.81 -0.78 -0.77 0.491 6 6 0.738 0.484 6.5 6.5 0.472 -0.75 -0.75 0.713 1.14 1.13 1.12 7.5 0.695 7.5 0.434 0.689 8 -0.69 8.5 0.683 -0.641.09 -0.6 -0.62 0.665 0.377 9 0.390 0.646 9.5 1.06 9.5 10 1.04 0.634 10 -0.61 0.321 0.92 0.561 12 -0.510.86 0.524 -0.4 -0.33 14 0.8 0.73 0.7 0.488 0.445 0.427 0.208 16 16 -0.24 -0.25 0.151 18 18 20 0.157 20 -0.21 -0.14 22 24 0.132 22 24 0.54 0.329 0.52 0.317 26 0.063 -0.1

TABLE 5 (cont.) SLUC TEST DATA LSB-15

		SLUC TEST DATA L	SB-15	LSB-15	
	LSB-15 Falling Head Tes	st		Rising Head Test	
Time(min)	Head Change(ft)	Head Ratio	Time(min)	Head Change(ft)	Head Ratio
28 30 33 36 38 40 41 44 44	-0.1 -0.09 2 -0.09 4 -0.04 5 -0.01 -0.02 -0.01 2 0.03 4 0.05 -0.02	0.063 0.057 0.057 0.025 0.006 0.013 0.006 -0.019 -0.031 0.013 0.013	28 30 32 34 36 38 40 42 44 46 48 50 52 54 56 68 70	0.17 0.15 0.18 0.15 0.14	0.305 0.268 0.268 0.262 0.220 0.213 0.207 0.171 0.183 0.177 0.159 0.159 0.152 0.152 0.110 0.122 0.110 0.091 0.091 0.085 0.110

## SLUG TEST DATA FORM

Location RMA	Name Andre Fiedler
Borehole No. LSB-34	Groundwater Elevation Before Test 14.75bto
Test Date 7/24/90	Total Casing Depth 28.3 ft btoc
Measuring Point toc	Borehole Diameter 10 in
Type of Test Falling/Rising head	Casing Diameter 4 in
Transductor Probe Serial No. 02813	Screened Interval 18 - 28 ft
Datalogger Test Run No. 2  (include time and date for identification purposes)	Sand Pack Interval 15.4 - 28.4 ft  Lithology Tested sand, silty to clay and
SF = 10.12 step 0 Fall off = 0.002 step 1 Risi	
transducer depth = 26 ft btoc $as_o = 12.01$ below swl	Slug depth (bottom) = 20 ft btoc

TABLE 6
SLUG TEST DATA LSB-34

LSB-34 LSB-34 Rising Head Test Falling Head Test Head Change(ft) Head Ratio Time(min) Head Change(ft) Head Ratio Time(min) -1.06 -1.06 0.0033 ŏ 0.0033 -1.06 0.0066 0 -1.150.0099 -0.3 -0.3 2.44 -0.28 -1.79 0.0133 0.0133 0.0166 -0.53 -0.91 0.02 0.02 -0.02 -0.38 -0.64 1.76 0.0266 -1.01 0.0266 0.03 -1 0.03 0.47 0.0333 -1.75 -1.73 0.92 0.72 0.75 0.75 0.05 0.0666 1.000 -1.540.0833 0.0666 -1.54 -1.73 -1.77 -1.74 -1.71 -1.76 1.000 0.0833 0.987 0.74 0.1 0.1166 0.973 0.73 0.73 0.73 0.1166 0.1333 0.1333 0.15 0.973 1.000 0.994 0.989 0.1666 0.73 0.72 0.72 0.72 0.72 0.71 0.960 0.1833 0.1666 0.960 0.1833 -1.74 -1.74 0.2166 0.2333 0.25 0.989 0.960 0.2166 0.2333 0.25 -1.74 -1.73 -1.72 -1.72 -1.72 -1.71 -1.71 -1.68 0.947 0.983 0.977 0.977 0.977 0.947 0.71 0.71 0.71 0.71 0.71 0.2666 0,2833 0.2666 0.947 0.2833 0.947 0.3 0.3166 0.972 0.972 0.966 0.933 0.3333 0.4167 0.3166 0.920 0.69 0.3333 0.920 0.5 0.5833 0.6667 0.75 0.69 0.955 0.938 0.926 0.920 0.4167 0.5 0.68 0.68 0.68 0.67 0.67 0.907 -1.65 0.5833 -1.63 -1.62 -1.6 -1.73 0.6667 0.907 0.909 0.8333 0.8333 0.9167 0.9167 0.893 1.051 -1.850.67 0.893 1 1.0833 0.893 -1.6 1.0833 0.67 1.1667 0.932 -1.64 -1.63 -1.65 -1.76 0.67 0.66 0.66 1.1667 1.25 0.926 1.25 0.880 0.938 0.880 0.880 0.867 1.4166 1.000 1.4166 0.66 -1.76 -1.69 -1.72 -1.72 -1.69 -1.68 -1.67 1.5 0.960 0.977 1.5 1.5833 0.65 0.867 0.65 0.65 0.64 0.64 0.977 1.6667 1.75 1.8333 1.9167 1.75 0.966 0.853 1.8333 .....0.960 0.853 1.9167 0.955 0.840 2.5 0.813 0.787 0.760 0.720 0.949 0.61 0.909 0.59 2.5 3 -1.54 0.841 3.5 -1.48 0.54 0.52 0.51 0.49 3.5 4 -1.44 -1.4 0.693 0.795 0.773 0.756 4.5 4.5 0.680 5.5 5.5 6.5 7.5 -1.36 5.5 0.653 -1.33 5.5 0.640 0.739 -1.3 -1.27 0.613 0.46 0.587 0.44 0.699 -1.23 -1.2 -1.17 0.41 0.4 0.38 0.547 0.682 7.5 0.533 8 0.665 0.659 0.648 8 0.507 8.5 -1.16 9.5 0.453 8.5 0.34 -1.14 -1.12 0.400 9 0.3 0.636 0.625 0.574 0.29 0.25 0.2 0.15 0.11 9.5 0.387 -1.1 -1.01 10 0.333 12 0.267 12 0.540 -0.95 14 16 -0.9 0.147 0.483 -0.85 0.04 0.053 -0.82 -0.77 -0.73 0.466 0.000 0 0.438 22 24 26 -0.06 -0.080 -0.120-0.09 26 0.409

TABLE 6 (cont.)

	LSB-34	SLUG TEST DATA	LSB-34	LSB-34 Rising Head Test	
71 (min)	Failing Head Tes	Head Ratio	Time(min)	Head Change(ft)	Head Ratio
Time (min)  28 33 34 36 38 40 44 46 48 50 56 66 67 77 77 77 77 78 80 82 84 88 890 992 94 100 110	-0.63 -0.63 -0.557 -0.557 -0.553 -0.551 -0.551 -0.44 -0.446 -0.446 -0.445 -0.446 -0.44	0.398 0.369 0.358 0.358 0.347 0.330 0.324 0.301 0.301 0.301 0.295 0.290 0.284 0.273 0.261 0.261 0.261 0.256 0.261 0.256 0.261 0.250 0.250 0.216 0.222 0.233 0.244 0.222 0.239 0.227 0.216	28 30 32 34 36 38 40 42 44 46 48 50	-0.15 -0.18 -0.22 -0.25 -0.31 -0.34 -0.39 -0.42 -0.43	-0.200 -0.240 -0.293 -0.333 -0.400 -0.413 -0.520 -0.573 -0.627 -0.653

## **SLUG TEST DATA FORM**

Location RMA		Name Andre Fiedler
Borehole No. LSB	-35	Groundwater Elevation Before Test 10.25bto
Test Date <u>7/23/90</u>		Total Casing Depth 30.2 ft btoc
Measuring Point to	oc	Borehole Diameter 10 in
Type of Test Fallin	ng/Rising head	Casing Diameter 4 in
Transductor Probe	Serial No. <u>02813</u>	Screened Interval 19.9 - 29.9 ft
Datalogger Test R	un No. 0 me and date for	Sand Pack Interval 14 - 31 ft
•	ion purposes)	Lithology Tested <u>clay, verry sandy to clay</u> silty sandy
SF = 10.12	step 0 Falling head	
off = $0.002$	sten 1 Rising head	

Slug depth (bottom) = 16.5 ft btoc

transducer depth = 25 ft btoc  $as_0 = 13.85$  below swl

TABLE 7 SLUC TEST DATA LSB-35

LSB-35	LUC TEST DATA	LSB-35	LSB-35	
Falling Head Tes			Rising Head Test	
Time(min) Head Change(ft) 0 -2.32	Head Ratio	Time(min) O	Head Change(ft) 1.04	Head Ratio
0.0033	1.000 1.000 1.000 0.994 0.982 0.982 0.982 0.9976 0.9971 0.9971 0.9953 0.9971 0.9953 0.9941 0.9924 0.9924 0.9924 0.8853 0.865 0.8859 0.8859 0.8859 0.8859 0.8859 0.782 0.7534 0.694 0.694 0.694 0.694 0.5553 0.5541 0.694 0.694 0.694 0.694 0.694 0.694 0.694 0.695	0.0033 0.0066 0.0099 0.0133 0.0166 0.0233 0.0266 0.0333 0.0666 0.08333 0.1166 0.1333 0.1566 0.2333 0.2166 0.2333 0.3166 0.2333 0.41675 0.8333 0.41675 1.5833 1.16667 1.3333 1.41665 1.5833 1.9167 1.8333 1.41665 1.5833 1.9167 1.8333 1.9167 1.8333 1.41665 1.5833 1.9167	0.98 -0.344 -0.346 -0.384 -0.384 -0.387 -0.3	1.000 1.000

TABLE 7 (cont.) SLUG TEST DATA LSB-35

Time(min) Head Change(ft) Head Ratio Time(min) Head Control Research Contr	Head Test nange(ft) Head 0.75 0.72 0.69 0.66 0.62	Ratio 0.475 0.456 0.437
28	0.75 0.72 0.69 0.66	0.475 0.456
28	0.72 0.69 0.66	0.456
44	0.55 0.55 0.55 0.55 0.55 0.45 0.44 0.38 0.37 0.33 0.33 0.33 0.33 0.229 0.225 0.225 0.225 0.225 0.225 0.225 0.225 0.225	0.418 0.392 0.386 0.367 0.348 0.329 0.316 0.225 0.2259 0.2253 0.2241 0.2234 0.225 0.229 0.196 0.196 0.196 0.158 0.146 0.158 0.146 0.146 0.146 0.146 0.147

## GROUND WATER OBSERVATION WELL REPORT

PROJECT RMA COE 89MC/14A  LOCATION Sec 36  Date Completed 6-25-90 Original Depth Inspected By T. Terry Date 6-28-90  Checked By Date	Page of Well No
Ground Elevation  Ground Elevation  Depth of surface casing pipe above ground surface  Type of surface casing.  NA  L.D. of riser pipe.  Type of surface casing.  Purple of surface casing.  Type of surface casing.  Type of surface casing.  Type of surface casing.  Purple of surface casing.  Type of surface casing.  Type of surface casing.  Purple of surface casing.  Type of surface casing.  Purple of surface casing.  Type of surface casing.  Purple of surface casing.  Elev./depth bottom of seal.  Type of sand pack.  Elev./depth bottom of seal.  Type of sand pack.  Elev./depth bottom of screened section.  Elev./depth bottom of screened section.  Elev./depth bottom of plugged blacetion.  Elev./depth bottom of sand column  Type of backfill below observation pipe.  Elev./depth of hole.	round NA  NA  NA  NA  NA  NA  NA  NA  NA  NA

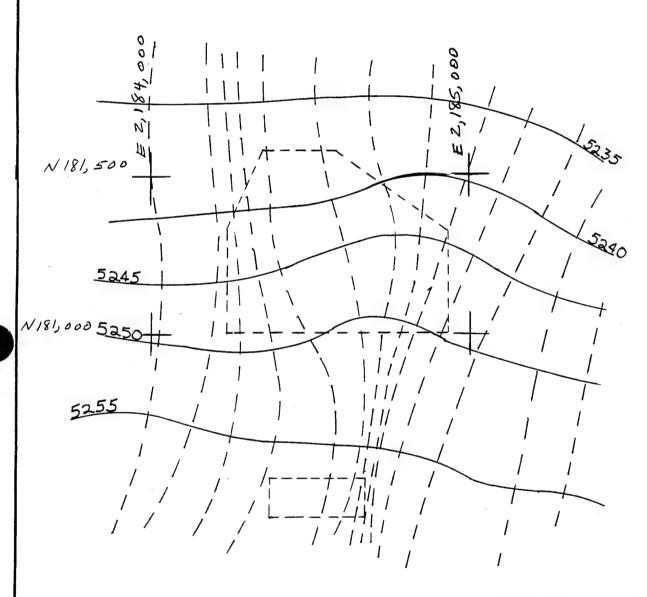
## GROUND WATER OBSERVATION WELL REPORT

PROJECT RMA COE 89MC/14A  LOCATION Sec. 36  Date Completed 6-27-90 Original Depth 28.4  Inspected By T. Terry Date 6-27-90  Checked By Date	Page of/ Well NoL S B - 34 Aquifer _Alluvia/  Depth Interval
Ground Elevation  Height of top of surface casing pipe above ground surface.  Depth of surface seal below g surface  Type of surface casing.  Depth of surface casing.  Type of surface casing.  Depth of surface casing.  Type of surface casing below  I. D. of riser pipe.  Type of riser pipe:  Type of sand pack.  Elev./depth bottom of seal.  Type of sand pack.  Elev./depth bottom of screened section.  Elev./depth bottom of screened section.	ground 11.0  nite NA  ground NA  fring 10.0  10.0  10.0  10.0  15.4  18.0  15.4  18.0  15.4  18.0  15.4  18.0  18.

## GROUND WATER OBSERVATION WELL REPORT

PROJECT RMA CO LOCATION SEC 36  Date Completed 6-29-90 Inspected By TAT	Original Depth <u>30.Z</u> Date <u>6-29-90</u>	Page of Well NoLSB-35 Aquifer _Alluvia
Ground Elevation	Elevation of top of surface compine above ground surface type of surface seal below surface.  LD. of surface casing. Type of surface casing. Type of surface casing below.  LD. of riser-pipe. Type of backfill:  Depth of borehole  Depth of borehole  Type of seal:  Elev./depth top of seal.  Type of sand pack.  Elev./depth top of screened seal.  Type of screened section.  Elev./depth bottom of screened seal.  LD. of screened section.  Elev./depth bottom of screened seal.  Elev./depth bottom of screened seal.  Elev./depth bottom of screened seal.  Describe openings  LD. of screened section.  Elev./depth bottom of screened seal.  Elev./depth bottom of sand call.  Elev./depth bottom of sand call.	Sing / riser   1.7     Iow ground   NA     NA   NA     NA   NA     NA   NA

OMAHA DISTRICT	COMPUTATION SHEET	CORPS	OF ENGINEERS
PROJECT RMA-LIME	SETTLING BASINS	SHEET NO. /	OF /
ITEM Flow Discoon	PRIOR TO ISOLATION CELL	BY JMC	DATE 8-10-90
TIOW CHARRIN	TATUR TO TOOLATION CELL	CHKD. BY	DATE



EQUIPOTENTIAL LINES

\_ \_ \_ FLOW LINES

° 50' 150' 300'

CEMRO-ED-GF

23 August 1990

MEMORANDUM FOR Director, Missouri River Division Laboratory

SUBJECT: Request for Laboratory Services - Serial No. M-1045(Mil), Lime Settling Basins Slurry Wall, Rocky Mountain Arsenal, Denver, Colorado

- 1. The purpose of this request for services is to determine the permeability of a proposed slurry wall at the Lime Settling Basins Site when exposed to contaminants in the groundwater at the site.
- 2. Funds were sent to the MRD Laboratory on MIPR number ENE 0544, dated 25 April 1990. The cost code to be used is RJ0027052780099.
- 3. It is requested that the tests designated on the enclosed Laboratory Test Request be performed and that one copy of the testing report be sent to this office Attention: (CEMRO-ED-GF). In addition, a copy of all soil classification results should be sent to CEMRO-ED-GC.

FOR THE COMMANDER:

Encl

JOHN W. MONZINGO, P.E. Chief, Geotechnical Branch Engineering Division MOSES/CEMRO-ED-GF

MONZINGO/CEMRO-ED-G

CF (wo/encl): CEMRO-ED-MA

# TEST REQUEST ROCKY MOUNTAIN ARSENAL TREATABILITY STUDY

- 1. <u>Introduction</u>. The following is an outline of the test procedures to be used for the Rocky Mountain Arsenal Lime Settling Basins Compatibility Study. Borrow material, slurry mix water, contaminated leachate, soil from the slurry wall borings and bentonite are already at the Lab. A schematic of the compatibility testing program is attached.
- 1.1. <u>Geotechnical Test Methods</u>. Where applicable, geotechnical testing shall be conducted in accordance with the Army Corps of Engineers Manual EM 1110-2-1906.
- 2. Determination of Bentonite Source. Potential bentonite sources must be premium-grade, ultrafine, natural sodium cation-based montmorillonite powders (Wyoming-type bentonite) that conforms to standards set forth in API Specification 13A, Sections 4, 8, and 9. Chemically treated bentonite will not be allowed. The bentonite samples at the Lab shall be tested for free swell using groundwater samples selected by the District. In addition, as a control, one free swell test shall be run on each bentonite sample using the anticipated slurry mix water. The free swell test method is described in EPA Report Number PB 87-229688 (EPA, 1987). The bentonite source which exhibits the least amount of variation between the control and contaminated groundwater free swell test will be used as the bentonite source for the backfill mixtures.
- 2.1. <u>Bentonite Slurry Preparation</u>. The bentonite slurry shall be prepared by mixing the slurry mix water with the previously selected bentonite source. The slurry shall be mixed with enough water to pass through a Marsh funnel in 40 to 50 seconds. The slurry shall be tested for density, moisture content, pH, and viscosity.
- 3. <u>Borrow Sources</u>. The borrow samples shall be stored in separate containers. All potential borrow material shall be tested for natural moisture content, Atterberg limits, grain size analysis (sieve and hydrometer methods), and specific gravity. No deleterious material will be allowed in any borrow material.
- 3.1 <u>Chemical Analysis</u>. The borrow material must be tested to verify it is free of contamination as determined by TCLP, TOC (Total Organic Carbon), sodium, calcium, magnesium, potassium, pH, and cation exchange
- 3.2. Preparation of Borrow Materials. The selected borrow will be oven-dried at 65 degrees Celsius for 2 to 4 days. The clays shall then be broken up, thoroughly mixed, and passed through a U.S. Standard Sieve No. 4. A sufficient quantity of oven dried material shall be retained for the optimization testing. The anticipated slurry mix tap water shall be added to the remainder of the dried and mixed materials until the original field water content is reached. The reconditioned borrow shall then be stored for 3 to 6 days in sealed containers at room temperature. During this storage period the samples should be mixed daily.

- 4. In Situ Slurry Wall Soil. Samples from the following Lime Settling Basins borings shall be thoroughly mixed to form one large sample: 11, 24, 9, 10, 26, and 18. This large sample shall be divided into two composite samples. Grain size analysis (sieve and hydrometer methods), Atterberg limits, and moisture content shall be run on each composite sample. Due to the consistency of the boring logs and field sieve analyses of the area, results of these two composite samples are expected to be very similar. One composite sample shall be used for optimization testing. Both samples will be used during permeameter testing (see paragraph 6).
- 5. Optimization Testing. Optimization tests will be performed to determine the most economical combination of materials for the backfill mixture. The percentage of fines, bentonite, coarse grained material, and water will be varied to produce the most economical backfill mixture which meets the 1 x 10<sup>-7</sup> cm/sec permeability criteria.

The optimization test procedure shall consist of the following steps:

Add sufficient oven dried (65 degrees Centigrade) borrow material to the selected oven dried composite sample so that the sample contains 20 % fines.

Add sufficient oven dried borrow material to produce 4 additional samples which contain 30, 40, 50, and 60 % fines respectively.

Place each sample in a constant value mold and datasets.

- -Place each sample in a constant volume mold and determine the respective dry densities. Plot percent fines vs. dry density.
- -Slurry mix water shall be added to each composite sample until the anticipated field water content is reached.
- Run fixed wall permeability tests on each of these samples. The permeability tests shall be run at a differential head of 2 psi. Each permeability specimen shall be sluiced with tap water to obtain a 3 to 6 inch slump prior to being placed in the fixed wall permeameter. The length of test hould be 8 to 24 hours.
- Based on the permeability test results, the District shall select a single mix which will most economically provide a permeability of 1 x 10  $^{-7}$  cm/sec or less after the addition of bentonite.
- The selected mix shall then be split into 3 samples. Two, 4, and 6 percent bentonite by dry weight shall be added to each of the 3 moist samples respectively. Each sample shall be sluiced with bentonite slurry to obtain a 3 to 6 inch slump. Each sample shall then be split into 2 specimens and fixed wall permeability tests run on each using the same test procedures outlined previously in this section. The length of test should be 24 to 48 hours. From this data, a plot of permeability vs. total percent bentonite will be made.
- A mixture which most economically meets or exceeds the permeability requirements will then be selected by the District for further evaluation as the backfill mixture.
- 5.1. <u>Borrow Soil Optimization Testing</u>. Optimization tests shall also be performed on the borrow material only. In this situation only the amounts of bentonite and water shall be varied. The last two steps of the above procedure shall also be carried out on the borrow material.
- 6. Preparation of Backfill Mixture For Compatibility Testing. One composite sample shall be permeameter tested at two percent higher bentonite content than selected during the optimization testing phase. The other imposite sample will be permeameter tested at twice that percent bentonite. We sets of compatibility tests (optimum+2% and twice [optimum+2%] bentonite)

- .also will be performed with the borrow soil only. Enough bentonite slurry shall be added to the reconditioned backfill mixture to achieve a slump in the range of 3 to 6 inches according to ASTM Test Method C 143-71 for determining concrete slump. The backfill mixture shall be stored in sealed containers at room temperature until loading into the permeameters for permeability testing.
- 7. Testing of Backfill Mixture. Atterberg limits, grain size analysis (mechanical analysis and hydrometer), moisture content, and specific gravity shall be run on the selected backfill mixture. A chemical analyses shall be performed on the selected backfill mixture as outlined in paragraph 3.1.
- 7.1. Initial Permeability Tests. One fixed wall permeability test shall be performed on each of the final backfill mixtures (borrow soil only and borrow soil plus in situ slurry wall soil) at optimum+2% bentonite using 'slurry mix water as the permeant to provide an initial estimate of the permeability. The length of this test shall be 24 to 48 hours.
- 8. Evaluate Permeant Effects. Three flexible wall permeameters shall be loaded with the selected backfill mixture, backpressure saturated, and leached with slurry mix water until one pore volume has passed through. Then two of the the backfill mixtures shall be leached with the contaminated groundwater samples until at least two pore volumes have passed through. The third specimen shall serve as a control test. It will be leached with only slurry mix water throughout the duration of the test. The time taken for each pore volume of fluid to move through the specimens shall be noted.

The following hydraulic gradients shall be applied to the specimens:

- 28 for the control sample which uses only slurry mix water as the permeant.

Confining pressure = 5 psi.

- 28 for one of the samples using ground water as the permeant. Confining pressure = 5 psi.
- 56 for the other sample using groundwater as the permeant. Confining pressure = 5 psi.

The specimens shall be placed into the cells manually in order to reduce the amount of entrapped air. Porous stones (25 to 50 micron opening), with glass fiber filter paper (Whatman type 2), placed on the sample side of the stones will allow undisturbed flow of the permeant through the backfill samples. Effluent from the permeameters will be tested for chemical constituents after each pore water volume has passed through each specimen. The following chemical constituents will be tested for: TOC, specific conductivity, bromide, pH, alkalinity, sodium, calcium, chloride, VOA (Volatile Organics), and BNA (Base Neutral Acid Extractible Organics). The latter two methods should check for chemicals on the Priority Pollutant list. These same tests should also be performed on the groundwater prior to permeameter testing. This data will be used to estimate the amount of contaminant adsorption/desorption taking place.

9. Pre-test and Post-test Sample Examinations and Photo
Documentation. Before the backfill mixture is loaded into the permeameters, comments on the general appearance, i.e. color and texture, of the material shall be recorded. The backfill mixture, before loading into the permeameters, shall be photographed. Photographs of the bentonite slurry shall also be taken.

As the permeameters are opened after completion of the tests, a visual examination of the samples shall be performed. The purpose of the visual examination is to determine whether months of testing has altered the general appearance of the sample. Similar comments to those mentioned above in the pre-test examination shall be recorded upon visual examination of the post-test backfill materials. Photographs of the backfill materials after testing shall be taken.

- 10. Reporting of Test Results. The results of the compatibility testing shall be presented to the Omaha District. The reported results should include the following:
- -Evaluation of bentonite sources.
- -Summary of bentonite slurry preparation.
- -Chemical and physical test results of borrow sources.
- -Summary of optimization testing performed and results of optimization testing.
- -Summary of backfill preparation procedures and results from tests performed on backfill mixture.
- -Results of all permeability tests performed on backfill mixtures including chemical analyses of the effluent. Permeabilities should be computed for each pore volume of fluid passing through each specimen.
- -Test results of permeability tests performed on the aquitard soil.
- -Pre-test and post-test sample examinations.

# ROCKY MOUNTAIN ARSENAL

#### IN SITU AND BORROW SOILS

GROUNDWATER

HEMICAL TESTS

(PARA. 8)

BENTONITE (PARA 2) FREE SWELL TESTS

CHOOSE 1

SLURRY PREPARATION

CHARACTERIZATION

BORROW SOIL

SEE BOX O, BORROW

SOILS ONLY CHART

# IN SITU SOILS

Combine soils From Following Borings: 11, 24, 9, 10, 26, 18

DIVIDE INTO a COMPOSITE SAMPLES
GRAIN SIZE, A.L., WZ OF EACH
COMPOSITE

# OPTIMIZATION TESTING (1) (PARA. 5)

OVEN DRY BORROW AND I COMPOSITE

MIX BORROW AND IN SITU SOIL TO

PRODUCE SAMPLES WITH, 20,

30, 40, 50, AND 60% FINES

PLOT DRY DENSITY US. % FINES

FIXED WALL PERMEABILITY TESTS

8-24 HRS, TAP WATER

SELECT MIX ECONOMICAL MIX

# OPTIMIZATION TESTING (2) (PARA. 5)

ADD BENTONITE SLURRY (2, 4, AND 67, BENTONITE, 3 TO 6 INCH SLUMP)

RUN & FIXED WALL PERMEAMETER TESTS FOR EACH TO BENTONITE, 14-48 HRS.

PLOT & US. % BENTONITE

SELECT LOWEST % BENTONITE WITH

### BACKFILL MIXTURE(S)

ONE COMPOSITE: OPTIMUM + 2% BENTONITE

BENTONITE

CHEMICAL É CHARACTERIZATION TESTE

INITIAL FIXED WALL PERMEABILITY
TEST (PARA. 7.1)

# PERMEAMETER TESTS (PARA. 8)

FOR BOTH MIXTURES:

CONTROL + MIX WATER ONLY, 1 = 18

GROUNDWATER PERMEANT, 1 = 28

GROUNDWATER PERMEANT, 1 = 56

CHEMICAL TESTS ON EFFLUENTS

REPORT (PARA. 10)

# TREATABILITY STUDY FLOW CHART ROCKY MOUNTAIN ARSENAL BORROW SOIL ONLY

CHARACTERIZATION TESTS (PARA. 3)

CHEMICAL TESTING (PARA 3:1)

SAMPLE PREPARATION (PARA. 3.2)

**(**1)

OPTIMIZATION TESTING

24-48 HR. PERMEABILITY TESTS
2, 4, AND 6 PERCENT BENTONITE

LOWEST % BENTONITE WITH

L = 1x10 Cm/SEC

**3** 

(4)

BACKFILL MIXTURE TESTING

CHEMICAL AND CHARACTERIZATION

(PARA 7.) OPTIMUM + 270 BENTONITE

TWICE OFTIMUM + 27 BENTONITE

24-48 HR. OFTIMUM + 270 BENTONITE

(PARA. 7.1)

#### PERMEAMETER TESTING (PARA. 8)

OPTIMUM +270 BENTONITE TWICE OPTIMUM +2% RENTONITE

CONTROL - MIX WATER ONLY CONTROL - MIX WATER ONLY

\$\lambda = 28\$

GROUND WATER PERMEANT | GROUND WATER PERMEANT

\$\lambda = 28\$

GROUND WATER PERMEANT | GROUND WATER PERMEANT

\$\lambda = 56\$

REPORT (PARA, 10)

# RMA LIME SETTLING BASINS COMPATIBILITY STUDY

- 1. Compare bentonites using free swell test and filter cake compatibilitity test (use fixed wall permeameters for filter cake test.)
- 2. Thoroughly composite samples from LSB0009, LSB0024, LSB0026, LSB0023, LSB0010, LSB0017, LSB0012, LSB0025).
- 3. Skip the "Dry Drusity vs % Fines" step using the constant.
  Volume molds due to poor correlations.
- 4. Skip the fixed wall permeability tests using non -bentonite mixes
- Make up 3 samples (2 specimens each) using the composite Institution material (From Step 2) and 0, 2, and 4% dry bentonite. Adjust composite moisture content to simulate field moisture prior to adding the dry bentonite. MRO geotech will provide the MRD Lab with the required field moisture content value.
- 6. Add 40 second march funnel viscosity bentonite slump to each of the 3 soil bentonite mixes (from step 5) to obtain an approximate 5" slump.
- 7. Run fixed wall permeability tests on the 3 soil-bentonite mixes (6 tests total).
- 8. Plot "Total % Bentinite vs. Permeability." If the permeability values meet MRO design requirements, proceed with step 17.

  If not, 90 to step 9. A4-9

- Repeat Steps 2 thru 7 using the Composite insitu material plus the Selected borrow material to obtain a new composite with approximately 10% more fines than the original insitu composite. Adjust moisture contents of insitu and borrow material to simulate field moistures. Prior to adding dry bentonite. MRO geotech will provide input into which borrow math. will be used along with the appropriate field moisture contents.
- Plot "Total 90 Bentonite vs Permeability." If the permeability values meet MRO design requirements, proceed with step 13.

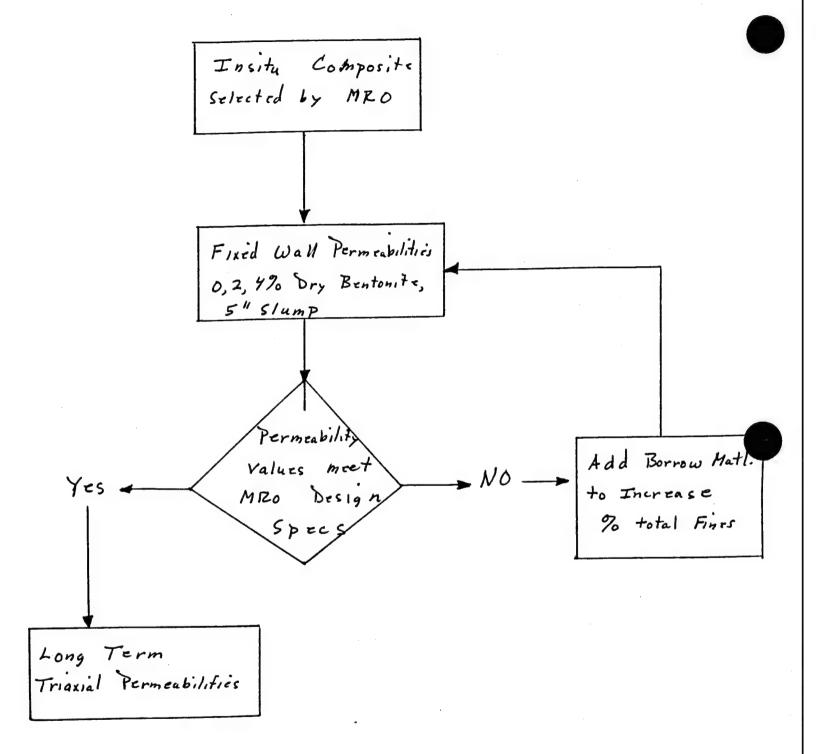
  If not, 90 to Step 11.
- Repeat staps 2 thru7 using the composite insity material plus borrow material to obtain a new composite with approximately 20% more fines than the original insity composite.
- Plot "Total % Bentonita vs Permeability." If the permeability, values meet MRO design requirements, proceed with step 13.

  If not, repeat steps 2 thru > using a new composite with approximately 30% mone fines than the original insite composite.
- . Run 3 triaxial long term permeabilities on the selected mix:
- . Control test (Site water only) Use selected mix w/90 bentonite resulting in a permeability near the upper limit of the design permeability. (e.g. 1×10-7 cm/sec @ 2% lentonite)
- ) Run the Second permeability test using the same mix as the

C) Run the third test using the selected mix w/% bentonite resulting in a permeability near the lower end of the permeability range for that mix. (e.g. 1×10-8 em)sec @ 4% bentonite). Run the test with leachate.

The Intent of the above revisions is to provide a more logical and hopefully more economical approach to selecting permeability mixes which better simulate actual slunny wall construction mixes. It assumes we start with a worst case insitu material and add up to 4% dry bentonite. Obviously, this should provide the most economical mix is design permeability requirements are met. The 4% cutoff is an arbitrary appear limit whereby we assume it would be more economical to add borrow fines rather than additional dry bentonite above this limit. If you agree with this revision, please submit a new test request with these parts changes to the MRD Lab as soon as possible.

Dave faces



# UPDATED TEST REQUEST ROCKY MOUNTAIN ARSENAL TREATABILITY STUDY

#### OCTOBER 10, 1990

- 1. <u>Introduction</u>. The following is an outline of the test procedures to be used for the Rocky Mountain Arsenal Lime Settling Basins Compatibility Study. Borrow material, slurry mix water, contaminated leachate, soil from the slurry wall borings and bentonite are already at the Lab. A schematic of the compatibility testing program is attached.
- 1.1. <u>Geotechnical Test Methods</u>. Where applicable, geotechnical testing shall be conducted in accordance with the Army Corps of Engineers Manual EM 1110-2-1906.
- 2. Determination of Bentonite Source. Potential bentonite sources must be premium-grade, ultrafine, natural sodium cation-based montmorillonite powders (Wyoming-type bentonite) that conforms to standards set forth in API Specification 13A, Sections 4, 8, and 9. Chemically treated bentonite will not be allowed. The bentonite samples at the Lab shall be tested for free swell and filter cake compatibility testing using groundwater samples selected by the District. In addition, as a control, one free swell test shall be run on each bentonite sample using the anticipated slurry mix water. The free swell test method is described in EPA Report Number PB 87-229688 (EPA, 1987). A bentonite source will be chosen for further testing based on free swell and filter cake compatibility results.
- 2.1. <u>Bentonite Slurry Preparation</u>. The bentonite slurry shall be prepared by mixing the slurry mix water with the previously selected bentonite source. The slurry shall be mixed with enough water to pass through a Marsh funnel in 40 to 50 seconds. The slurry shall be tested for density, moisture content, pH, and viscosity.
- 3. <u>Borrow Sources</u>. The borrow samples shall be stored in separate containers. All potential borrow material shall be tested for natural moisture content, Atterberg limits, grain size analysis (sieve and hydrometer methods), and specific gravity. No deleterious material will be allowed in any borrow material.
- 3.1 <u>Chemical Analysis</u>. The borrow material must be tested to verify it is free of contamination as determined by TCLP, TOC (Total Organic Carbon), sodium, calcium, magnesium, potassium, pH, and cation exchange capacity.
- 3.2. Preparation of Borrow Materials. Enough borrow (clay and random fill) for optimization testing will be oven-dried at 65 degrees Celsius for 2 to 4 days. The clays shall then be broken up, thoroughly mixed, and passed through a U.S. Standard Sieve No. 4. The anticipated slurry mix tap water shall be added to the dried and mixed materials until the original field water content is reached. The reconditioned borrow shall then be stored for 3 to 6 days in sealed containers at room temperature. During this storage period the samples should be mixed daily.

- 4. <u>In Situ Slurry Wall Soil</u>. Samples from the following Lime Settling Basins borings shall be thoroughly mixed to form one composite sample: 11, 24, 9, 10, 26, and 18. Grain size analysis (sieve and hydrometer methods), Atterberg limits, and moisture content shall be run on this composite sample.
- 5. Optimization Testing. Optimization tests will be performed to determine the most economical combination of materials for the backfill mixture. The percentage of fines, bentonite, coarse grained material, and water will be varied to produce the most economical backfill mixture which meets the 1 x  $10^{-7}$  cm/sec permeability criteria.

The optimization test procedure shall consist of the following steps:

- a. Prepare 3 samples (2 specimens each) using the composite insitu material. If additional water is necessary to simulate field moisture content, RMA tap water will be added at this time. Dry bentonite will be added to the samples to obtain 0, 2, and 4% bentonite by weight.
- b. Add bentonite slurry with a viscosity of 40 seconds (Marsh funnel) to each sample (from step a) to obtain an approximate 5 inch slump.
- c. Run fixed wall permeability tests on the 3 soil-bentonite mixtures (6 tests total). Test length will be 24 to 48 hours.
- d. Plot "Total Percent Bentonite vs. Fermeability". If the permeability values are not less than or equal to 1 x  $10^{-7}$  cm/sec, proceed with step e. Otherwise go on to paragraph 5.1.
- e. Repeat steps a through c using the composite insitu material plus the clay borrow material to obtain a new composite with approximately 10% more fines than the original insitu composite. Adjust moisture contents as necessary to simulate field moisture conditions.
- f. Plot "Total Percent Bentonite vs. Permeability". If permeability values are not less than or equal to 1 x  $10^{-7}$  cm/sec proceed with step g. Otherwise go on to paragraph 5.1.
- g. Repeat steps a through c using the composite insitu material plus the clay borrow material to obtain a new composite with approximately 20% more fines than the original insitu composite. Adjust moisture contents as necessary to simulate field moisture conditions.
- h. Plot "Total Percent Bentonite vs. Permeability". If permeability values are not less than or equal to 1 x  $10^{-7}$  cm/sec proceed with step i. Otherwise go on to paragraph 5.1.
- i. Repeat steps a through c using the composite insitu material plus the clay borrow material to obtain a new composite with approximately 30% more fines than the original insitu composite. Adjust moisture contents as necessary to simulate field moisture conditions.
- j. Plot "Total Percent Bentonite vs. Permeability". If permeability values are not less than or equal to 1  $\times$  10<sup>-7</sup> cm/sec notify MRO-GF.
- 5.1. <u>Borrow Soil Optimization Testing</u>. Optimization tests shall also be performed using the random fill borrow material in place of the insitu soil.
- 5.2. If none of the insitu soil-fines-bentonite mixtures results in a permeability on the order of magnitude of 10<sup>-7</sup> cm/sec while mixture(s) of random fill borrow-fines-bentonite do, then long-term permeability tests will be performed using only random fill borrow as the principal soil constituent. If the desired permeability is obtained by mixtures including insitu soil and

random fill borrow, long-term permeability tests will be performed using both principal soil constituents.

- 6. <u>Preparation of Backfill Mixture For Compatibility Testing</u>. Soils to be used for long-term permeability tests shall be prepared as specified in paragraph 3.2, Preparation of Borrow Materials. Prepared backfill mixtures shall be stored in sealed containers at room temperature until loading into the permeameters for permeability testing.
- 7. Testing of Backfill Mixture. Atterberg limits, grain size analysis (mechanical analysis and hydrometer), moisture content, and specific gravity shall be run on the selected backfill mixtures.
- 8. Evaluate Permeant Effects. Three flexible wall permeameters shall be loaded with the backfill mixture, backpressure saturated, and leached with slurry mix water until one pore volume has passed through. Then two of the the backfill mixtures shall be leached with the contaminated groundwater samples until at least two pore volumes have passed through. The third specimen shall serve as a control test. It will be leached with only slurry mix water throughout the duration of the test. The time taken for each pore volume of fluid to move through the specimens shall be noted. The hydraulic gradient will be 28 with a confining pressure of 5 psi. The mixtures shall be as follows:
- a. Control (tap water only) the selected mix with the percent bentonite which produced a permeability near 1 x  $10^{-7}$  cm/sec during optimization testing.
- b. Same mix and percent bentonite as control with contaminated groundwater as permeant after the first pore volume.
- c. Same mix as control with a higher bentonite content that produces a permeability close to 1 x  $10^{-8}$  cm/sec, with contaminated groundwater as permeant after the first pore volume.

The specimens shall be placed into the cells manually in order to reduce the amount of entrapped air. Porous stones (25 to 50 micron opening), with glass fiber filter paper (Whatman type 2), placed on the sample side of the stones will allow undisturbed flow of the permeant through the backfill samples. Effluent from the permeameters will be tested for chemical constituents after each pore water volume has passed through each specimen. The following chemical constituents will be tested for: TOC, specific conductivity, bromide, pH, alkalinity, sodium, calcium, chloride, VOA (Volatile Organics), and BNA (Base Neutral Acid Extractible Organics). The latter two methods should check for chemicals on the Priority Pollutant list. These same tests should also be performed on the groundwater prior to permeameter testing. This data will be used to estimate the amount of contaminant adsorption/desorption taking place.

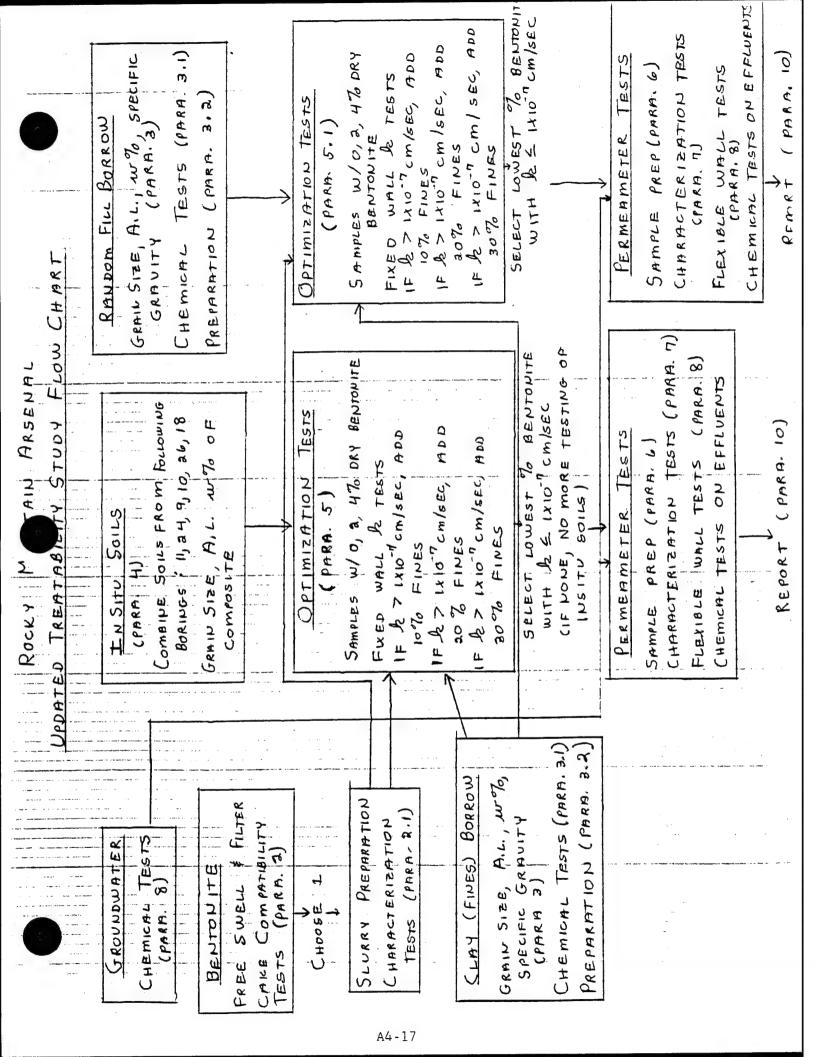
9. Pre-test and Post-test Sample Examinations and Photo

Documentation. Before the backfill mixtures are loaded into the permeameters, comments on the general appearance, i.e. color and texture, of the material shall be recorded. The backfill mixture, before loading into the permeameters, shall be photographed. Photographs of the bentonite slurry shall also be taken.

As the permeameters are opened after completion of the tests, a visual examination of the samples shall be performed. The purpose of the

visual examination is to determine whether months of testing has altered the general appearance of the sample. Similar comments to those mentioned above in the pre-test examination shall be recorded upon visual examination of the post-test backfill materials. Photographs of the backfill materials after testing shall be taken.

- 10. Reporting of Test Results. The results of the compatibility testing shall be presented to the Omaha District. The reported results should include the following:
- -Evaluation of bentonite sources.
- -Summary of bentonite slurry preparation.
- -Chemical and physical test results of borrow sources.
- -Summary of optimization testing performed and results of optimization testing.
- -Summary of backfill preparation procedures and results from tests performed on backfill mixture.
- -Results of all permeability tests performed on backfill mixtures including chemical analyses of the effluent. Permeabilities should be computed for each pore volume of fluid passing through each specimen.
- -Pre-test and post-test sample examinations.



EA ENGINEERING.
SCIENCE, AND
TECHNOLOGY, INC.

15 Loveton Circle Sparks, MD 21152 (301) 771-4950

### LETTER OF TRANSMITTAL

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Gregory E. Johnson, P.E., CHMM If enclosures are not as noted, kindly notify us at onc Project Manager

## GEO-CON'INC.

GEOTECHNICAL CONTRACTING

S9-H029 Letter No. 045

August 8, 1990

Department of the Army Baltimore District, Corps of Engineers P. O. Box 242 Fort George G. Meade, MD 20755-0242

Attn: Mr. Bob Craig



Bentonite Clay
API 13A Section 5
Slurry Wall
Kane and Iombard Superfund Site
Contract DACW45-89-C-0507
Baltimore, Maryland

Dear Mr. Craig:

As you know a new bentonite product was specified for use in the slurry wall on the above referenced project. This new product is tentatively specified by the American Petroleum Institute (API) under Specification 13A, Section 5: Nontreated Bentonite (Tentative). The usual product is premium grade, 90 bbl/ton yield, API 13A Section 4 bentonite clay. This letter presents our evaluation of this product based on our experience at the Kane and Lombard project.

At the Kane and Lombard project we mixed the bentonite slurry to a 40 MFV in our 5 cy colloidal mixer. This mixer fully hydrates the slurry during the retention time of the plant. Our excavations encountered two different areas; 1) a 15 ft. deep excavation through primarily clay, and 2) a 30 ft. deep excavation through primarily refuse. Typically, we would expect a usage factor of 4-5 pounds of bentonite per square foot in the clay excavation and 10-15 pounds per square foot in the refuse. On this project our usage was 10-12 pounds per square foot in both areas. In addition, in the refuse our filtrate loss in the trench occasionally exceeded 40 cc, however, our trench was stable and we had no cave-ins. All permeability tests were acceptable and a high quality slurry wall is now in place.

We find two areas of concern with the performance of this new bentonite product. First, in the area of normal slurry trenching, the usage was excessive and unexpected. Second, in the refuse area the usage did not respond adequately to the refuse conditions; i.e. our filtrate was excessive and a cave-in was only avoided by our extra efforts. Considering the premium price of this new product, the results described above were very disappointing.

A review of the Section 5 specification may provide some of the answers. This clay is treated with a deflocculant (sodium hexametaphosphate) prior to testing the yield. This technique results in erroneous and misleading results and is totally different from any other API test. In our opinion, the Section 5 product performed like a sub-API 13A product normally used in the foundry industry (yield = 50-80 bbl/ton).

## JEO-CON'INC.

August 8, 1990 Page 2

We would not recommend this product for slurry trenching. If the aim of this new specification is a better product, the specification has failed. If bentonite/leachate compatibility is a concern, it is recommended engineering practice to test the compatibility of various bentonite products prior to specifying the bentonite. Therefore, an adequate testing program will determine what type of bentonite is acceptable. Our solution to buying quality bentonite has been to rely on a limited number of vendors with a proven product and perform regular testing of our own. Our suppliers of API 13A, Section 4 bentonite have a high quality base clay and add only about 0.5 pounds of polymer additive per ton of bentonite (0.025%). This generally results in a much more predictable with proprietary treatments. As slurry specialists we cannot recommend bentonites with excessive polymer treatment, however, bentonite is, after all, only soil and specialists in the field and knowledgeable engineers to produce quality installations.

This letter is provided to you for informational purposes only, no response is necessary. We do, however, wish to register our dissatisfaction with this new product and specification so that the Corps of Engineers and API can take propriate measures in the future.

Sincerely,

GEO-GON, INC

Steven R. Day Slurry Wall

Group Manager

David A. Sandstrom

Liner Division
Group Manager

SRD/DAS/lmw

cc: American Petroleum Institute Production Department 2531 One Muir Place Dallas, TX 75202-3904 Attn: Mike Laudermilk

J. Kohli

#### ZERO ACCIDENTS

#### SECTION 02214

#### SOIL-BENTONITE SLURRY CUTOFF WALL

#### INDEX

1.	SCOPE.	8.	NOT USED.
2.	APPLICABLE PUBLICATIONS.	9.	MATERIALS.
3.	GEOTECHNICAL SITE CONDITIONS.	10.	EQUIPMENT.
4.	DEFINITIONS.	11.	SLURRY TRENCH CONSTRUCTION.
5.	SUBMITTALS.	12.	QUALITY CONTROL.
6.	QUALIFICATIONS FOR SLURRY TRENCH	13.	QUALITY ASSURANCE.
	CONSTRUCTION.	14.	MEASUREMENT.
7.	SUBSURFACE INVESTIGATIONS.	15.	PAYMENT.

- SCOPE. The work covered by this section of the Specifications consists of furnishing all parts, labor, equipment, and materials and of performing all operations in connection with constructing the soil-bentonite slurry cutoff wall, hereinafter referred to as the slurry trench, in accordance with these specifications and contract drawings.
- APPLICABLE PUBLICATIONS. The following publications of the issues listed below, but referred to thereafter by basic designation only, form a part of this specification to the extent indicated by the reference thereto.

AMERICAN PETROLEUM INSTITUTE (API) STANDARD SPECIFICATIONS. 2.1. Recommended Practice Standard Procedures for Code RP13B 12th Ed. Sept 1988 Testing Drilling Fluids; and Supplements Specification for Oil-Well Drilling Fluid Spec. 13A Sections 3,5,6, Materials

7, and 8 12th Ed. Sept 1988

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2.2.	AMERICAN SOCIETY	FOR TESTING AND MATERIALS (ASTM) STANDARDS.
	D 1140-57	Materials Finer than 75 µm (No. 200) Sieve in
		Mineral Aggregates by Washing
	C 136-83	Sieve Analysis of Fine and Coarse Aggregates
	D 2217-66	Wet Preparation Method
	C 143-78	Slump of Portland Cement Concrete
	D 698-78	Test for Moisture-Density Relations of Soils a

Soil-Aggregate Mixture, Using 5.5-pound Hammer and 12-inch Drop

D 422-63 Particle-Size Analysis of Soils D 1586-67 Standard Penetration Test

D 1587-83 Thin Walled Tube Sampling of Soils

Liquid Limit, Plastic Limit, and Plasticity D 4318-84 Index of Soils

2.3. CORPS OF ENGINEERS MANUALS.

> EM 1110-2-1906 Laboratory Soils Testing

Appendix VI

(Dated 20 August with Change 2)

EM 1110-2-3506 Grouting Technology

- 7.6. DISPOSAL OF DRILL CUTTINGS. All drill cuttings will be handled and disposed in accordance with SECTION: HANDLING AND DISPOSAL OF CONTAMINATED MATERIALS.
- 8. NOT USED.

9. MATERIALS. The requirements for the materials to be utilized in the slurry trench construction are as follows.

- 9.1. BENTONITE. The bentonite shall be sodium cation base montmorillonite powder (Premium Grade Wyoming-type bentonite) that conforms to the standards set forth in API Specification 13A, Section 3, 5, 6, 7, and 8 as last revised. No chemically treated bentonite will be allowed. The Contractor shall furnish to the Contracting Officer a certificate of compliance and a copy of the test reports from the bentonite manufacturer for each lot of bentonite shipped to the site stating that the bentonite complies with all applicable standards. No bentonite from the bentonite manufacturer shall be used prior to acceptance by the Contracting Officer. All bentonite will be subject to inspection, sampling, and verification of quality of testing by or under the supervision of the Government. Bentonite not meeting specifications shall be promptly removed from the site of the work and replaced with bentonite conforming to specifications requirements at the Contractor's expense. Bentonite shall be protected from moisture during transit and storage.
- 9.2. WATER. The Contractor shall supply all water required for mixing with bentonite to produce slurry. The water shall be clean, fresh, and comply with the standards specified below.

a. A pH equal to  $7.0\pm1.0$ .

b. Total dissolved solids not greater than 500 parts per

million.

c. Oil, organics, acids, alkali, or other deleterious substances not greater than 50 ppm each.

d. Hardness less than or equal to 50 ppm.

e. Ground water from the site is specifically excluded

from use.

The Contractor shall furnish water quality test results for water used for mixing the bentonite slurry to assure conformance with the above limits.

- 9.3. BENTONITE SLURRY. The bentonite slurry for supporting the sides of the trench and that mixed with the backfill shall consist of a stable colloidal suspension of powdered, premium-grade natural bentonite in water. It is the responsibility of the Contractor that the slurry meets the necessary properties. The properties of the slurry used in all construction sequences shall be in accordance with the testing procedures described in API Code RP13B and shall conform to the following requirements:
- 9.3.1. Initial Bentonite Slurry Mixture. At the time of introducing bentonite slurry into the trench excavation, the slurry mixture shall have a minimum apparent viscosity of 40 seconds as measured by the Marsh funnel. The slurry density shall be a minimum of 65 pounds per cubic foot. The water loss shall not be greater than 30 cubic centimeters in 30 minutes as measured by a filter press at 100 psi. The pH shall not be less than 8.0. Mixture adjustment shall conform to the requirements in subparagraph: Additional Bentonite.
- 9.3.2. Trench Bentonite Slurry Mixture. The minimum apparent viscosity of the bentonite slurry mixture in the trench at any time shall be 40 seconds as measured by the Marsh funnel and the maximum shall be low enough to flow through the Marsh funnel. The density of the slurry mixture at the time

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## APISTURE DETERMINATIONS

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TARE NO.						_	<u> </u>					1 6
TARE PLUS WET SOIL  TARE PLUS DRY SOIL  TARE PLUS DRY SOIL  WATER  WALL  DRY SOIL  WATER CONTENT, WALL  SAVE  TARE PLUS WET SOIL  WATER CONTENT, WALL  SAVE  TARE PLUS WET SOIL  WATER CONTENT, WALL  SAVE  TARE PLUS DRY SOIL  WATER CONTENT, WALL  SAVE  TARE PLUS DRY SOIL  WATER CONTENT, WALL  SAVE  TARE PLUS WET SOIL  TARE PLUS DRY SOIL  WALL  TARE PLUS DRY SOIL  WALL  TARE PLUS WET SOIL  SAVE  TARE PLUS WET SOIL  TARE PLUS WET SOIL  SAVE  TARE PLUS DRY SOIL  WATER  DRY SOIL  WATER CONTENT, WALL  TARE PLUS DRY SOIL  TA						-		7	3			-
TARE PLUS DRY SOIL  WATER  TARE  DRY SOIL  WATER CONTENT, %  NUMBER OF BLOWS  NATURAL WATER CONTENT  TARE PLUS DRY SOIL  TARE PLUS DRY SOIL  NATURAL WATER CONTENT  TARE DRY SOIL  DRY SOIL  WATER CONTENT, %  WATER CONTENT, %  PLASTIC LIMIT  REMARKS						$\dashv$	77714	2 1041				
WATER WATER W W / .505 /.55  DAYSOIL W J / .505 /.55  WATER CONTENT. W W 45.5 45.3  NUMBER OF BLOWS  SAVE Y 1/2 0 4 SOIL   S 10 20 30 40  NUMBER OF BLOWS  NATURAL WATER CONTENT. W 2 2 3 2 7 7 7 7 7 7 7 7 7 7 7 7 7 7 7 7	- S					-	5 774					
DAY SOIL WATER CONTENT, IX  WATER CONTENT, IX  NUMBER OF BLOWS  SAVE WH2 O 4 SOIL  SAVE WH2 O 5 SOIL  LL 453  PL 27.4  PL 27.4  PL 17.9  Symbol from platicity chart  A STARE NO.  TARE PLUS WET SOIL  TARE PLUS DAY SOIL  WATER CONTENT, IX  WATER CONTENT, IX  WATER CONTENT, IX  PLASTIC LIMIT  WATER CONTENT, IX  WATER CONTENT, IX  WATER CONTENT, IX  PLASTIC LIMIT  WATER CONTENT, IX  WATER CONTENT, IX  PLASTIC LIMIT  WATER CONTENT, IX  WATER CONTENT, IX  PLASTIC LIMIT  REMARKS	E E	WAT			w		9.117	7,00				
DAY SOIL WATER CONTENT, IX  WATER CONTENT, IX  NUMBER OF BLOWS  SAVE WH2 O 4 SOIL  SAVE WH2 O 5 SOIL  LL 453  PL 27.4  PL 27.4  PL 17.9  Symbol from platicity chart  A STARE NO.  TARE PLUS WET SOIL  TARE PLUS DAY SOIL  WATER CONTENT, IX  WATER CONTENT, IX  WATER CONTENT, IX  PLASTIC LIMIT  WATER CONTENT, IX  WATER CONTENT, IX  WATER CONTENT, IX  PLASTIC LIMIT  WATER CONTENT, IX  WATER CONTENT, IX  PLASTIC LIMIT  WATER CONTENT, IX  WATER CONTENT, IX  PLASTIC LIMIT  REMARKS	⊒ C N Z	TARE				"	1.505	1.53				
NUMBER OF BLOWS  SAVE  S	=		SOIL		W	3						
SAVE 47 H2 O & SOIL					٧	<u> </u>	45,5	453				1
NUMBER OF BLOWS  PLASTIC LIMIT  RUN NO.  TARE PLUS WET SOIL  TARE PLUS DRY SOIL  WATER  CONTENT  TARE PLUS DRY SOIL  WATER  DRY SOIL  WATER CONTENT, S  PLASTIC LIMIT  REMARKS		NUMBER	OF BLOWS			_	130	125				<del></del>
PLASTIC LIMIT  RUN NO.  1 3 3 4 5 CONTENT  TARE NO.  TARE PLUS WET SOIL  TARE PLUS DRY SOIL  WATER  WATER  DRY SOIL  WATER CONTENT  WATER  DRY SOIL  WATER CONTENT  WATER  PLASTIC LIMIT  NATURAL WATER  WATER  ON ATURAL WATER  ON						486	R OF BLOWS		30 40		PL 27 PI 17 Symbol from	3.4.9
RUN NO.  TARE NO.  TARE PLUS WET SOIL  TARE PLUS DRY SOIL  WATER  DRY SOIL  WATER CONTENT, %  WATER CONTENT, %  PLASTIC LIMIT  REMARKS							PLASTIC	LIMIT				NATURAL
TARE PLUS WET SOIL  TARE PLUS DRY SOIL  WATER  TARE  DRY SOIL  WATER CONTENT, %  WATER CONTENT, %  PLASTIC LIMIT  TARE PLUS WET SOIL  3.145  3.286  3.792  2.914  WW  ATRE  DRY SOIL  W S  ATRE  DRY SOIL  WATER CONTENT, %  WATER C		RU	IN NO.					3	3	4	5	CONTENT
TARE PLUS DRY SOIL  WATER  WATER  TARE  DRY SOIL  WATER CONTENT, %  PLASTIC LIMIT  REMARKS		TA	RE NO.			$\Box$	7,,,,	4				
PLASTIC LIMIT  REMARKS  DRY SOIL  W 3  A 7.8 D 7.0  PLASTIC LIMIT	S	TARE PL				4	3.145					
PLASTIC LIMIT  REMARKS  DRY SOIL  W 3  A 7.8 D 7.0  PLASTIC LIMIT	AM	TARE PL		IL .	Iw	_	2.192	2717				
PLASTIC LIMIT  REMARKS  DRY SOIL  W 3  A 7.8 D 7.0  PLASTIC LIMIT	GR	TARE	<u> </u>			w	533	1001				
WATER CONTENT, % W 27.8 27.0 PLASTIC LIMIT REMARKS	Z	DAY	SOIL		w	+	700	1158/				
PLASTIC LIMIT  REMARKS	1			,		-	278	27.0			1	
REMARKS ————————————————————————————————————						1		Sa 1. V				
·	RE											
TECHNICIAN COMPUTED BY CHECKED BY						•						
	TE	CHNICIAN					COMPUTED	3Y		CHECKE	BY	

ENG FORM 3838

A6-3

PLATE III-1

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## GRAIN SIZE ANALYSIS

GCO. 1					•
9 22	90				
Date: 9-20-				(	H
Project No.1.			•		
Project: Ko	OCKY MOUNTAIN	ARSENAL		•	
Location of S	Sample: COELSR	0025			
Sample Descri	letion: MoitleD.	LIGHT BROWN	£ C.		
USCS:	AASHTO:	· SABON	SURRY		
Liquid Limit:	Plastic	Indove	<b>J</b>		
Remarks: Con	nPOSITE 2.5', 5', 7	5'10'15' 10			
SA	WE HZO & SO	14	O		
	. ,				
Mechanical					
☐ Hydrometer	analysis				
	Data She	et 1 - Mechanica	1		
•	Initial Sam	mple	After Wash		
Dry Sample and	d Tare=				
Tares				-	
Dry Sample Hei	Ight= 105.8				
Calculated -28		•			
Tare For Cumul	ative Height Retains	d=			
				<del></del>	
				•	
	MECHA	ANICAL ANALYSIS		•	
J.S. STANDARD S	TRVE				
IZE(MM)	SIEVE NO.				
76.2 ;		SAMDIE um	4		
38.1	3 INCH 1 1/2 INCH	SAMPLE WT.3	COARSER 0.0	% FINER	
19.1	3/4 INCH	0.0	0.0	100.0	
9.52	3/8 INCH	0.0	0.0	100.0	
PAN	NO. 4	0.0	0.0	100.0	
TOTAL		0.0	0.0	100.0	
CTOR		0.0	0.0	100.0	
.10		0.0		•	
. 20	2.00	0.9452			
. 40	0.84	5.1 8.7	4.8	95.2	
. 80	0.42	13.8	8.2	91.8	
. 200	0.177	35.5	13.0	87.0	
PAN	0.074	69.7	33.6	66.4	
•		105.8	65.9	34.1	
er:			100.0	0.0	

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Г							PLASTIC LIN				
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PR	OJEC	NO. COE	1 100	TUNT	AIL	) HRSE	NAL			Compo	SITE
30	RING	NO. COE	SBC	202				S	AMPLE NO.	Compo	5/12
						L	IQUID LIMIT				
		RUN NO.				1	2	3	4	5	6
		TARE NO.				7202	2 499		<del> </del>		
۶ ا چ	TAI	RE PLUS WET S				6301	7.133				
WEIGHT N GRAMS	1	WATER			W "		7.17.00				
<b>≥</b>	TAI	RE				1.505	1.533				ļ
		DRY SOIL			w .	221	33.3				
_		TER CONTENT,			w	33.4	25				
1	1401					33.1	<u> </u>				
	WATER CONTENT, W, %	5		10	NUMBI	ER OF BLOWS	20	30 40		PL 14 PI 18 Symbol from plasticity chart  *Med	7 3,3
		RUN NO.				1	2	3	4	5	CONTENT
		TARE NO.				4.2510	4.594			ļ <u>-</u>	
L S	TAR	E PLUS WET SO				3 993	4:100			1	1
WEIGHT IN GRAMS	W	ATER			w w						
3 5	TAR				w .	1.506	1.525			-	
	0	RY SOIL	*		w ;	14-6	NV		<del> </del>		
		STIC LIMIT	-		**	. 1.20	1710				
RE		:s									
L		CIAN				COMPUTED	BY		CHECKED	BY	
_ 'E	CHINIC										PI ATE III

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A6-5

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## GRAIN SIZE ANALYSIS



0 24 45			•		
Date: 9-26-90					
Project No.:			•		
Project: Rucky	MOUNTAIN	ARSENAL			B
	·: COELSE Ød	23	Co	MPOSITE	
Sample Description	n: BROWN				•
USCS:					
Liquid Limit:	_ Plastic I	ndex:			
<b></b>	•				
Mechanical ana					
☐ Hydrometer ana	lysis				Ţ
•	Data Sheet	1 - Mechanica	1		· ·
	Initial Samp	le g	After Wash		*
Dry Sample and Tax	- 0 =				
Tare=					
Dry Sample Height	113.0		·	-	
Calculated -200=_				<b></b>	•
Tare For Cumulativ	e Height Retained			•	
		Clave Well	tht Tare	Cun.	%
	MECHAN	ICAL ANALYSIS	•	_	
U.S. STANDARD SIEVI		ANALISIS			
SIZE (MM)					
76.2 ;	SIEVE NO.	CANEDO -			
38.1	3 INCH 1 1/2 INCH	SAMPLE WT.		% FINER	
19.1 9.52	3/4 INCH	0.0	0.0 0.0	100.0	
4.76	3/8 INCH	0.0	0.0	100.0	
PAN	NO. 4	0.0	0.0	100.0	
TOTAL		0.0	0.0	100.0	
FACTOR		0.0	0.0	100.0	
10.10		0.0			
10. 20	2.00	0.8850 0.0			
0. 40	0.84	1.4	0.0	100.0	
0. 80	0.42 0.177	11.0	1.2	98.8	
0.200	0.074	43.2	9.7	90.3	
PAN	01017	79.9	38.2 70.7	61.8	
iter:		113.0	100.0	29.3 0.0	
ilue: 113				V.0	

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	1	m-36 31	Y .	For use of thi	PLASTIC LII	MII 1E515 1110-2-1906.			
- [			A.N				DATE	-20-9t	
		HOJECT ROCKY	MOUNT SB ODZ	TAIN FI	RSENAL	·		0	
	В	ORING NOCOEL	SR DOZ	22	•		SAMPLE NO	Compo	SITE
7	-				IQUID LIMIT				
ŀ		RUN NO.		1 1	2	3	4	5	6
-		TARE NO.		la:	10		<del>                                     </del>		-
t		TARE PLUS WET SOIL		10:503	7778		<del>                                     </del>	<b></b>	
	WEIGHT N GRAMS	TARE PLUS DRY SOIL		5,383	5.915				
	5	WATER	w "	,					
	Ž	TARE		11528	1.538				
L		DRY SOIL	w	1 00 /	39 0		-		
-		NUMBER OF BLOWS	w	33	23.7			-	1
-		NUMBER OF BLOWS			2 1	Carry	1		<u> </u>
			( SA	VE H	20 8	5012			
1				48.8	29.1				
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		*						20	
4		3						11 <u>29</u>	
		<u> </u>		11111		+++++	16.1		1
						<del>                                      </del>		1 (6	·/
1		WATER CONTENT, W, %			++++++	<del>                                      </del>		. ^	a
ı		<u> </u>						, 12	<u>, 7                                    </u>
ļ									
		<b>§</b>			<del>++++++</del>	<del>-1-1-1-1-1-1-1-1-1-1-1-1-1-1-1-1-1-1-1</del>		ymbol from	
ı							P	lasticity chart	
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1								Tice	
1				<del>1-1-1-1-1-1</del>	<del></del>			Tou	4~
		5	10		20	30 40			6
1		•			20	30 40			
ł			NUMB	ER OF BLOWS					
-	_			PLASTIC I	LIMIT				NATURAL
H		RUN NO.		1	2	3	4	5	WATER
1		TARE NO.		11	12		· · ·		CONTENT
	٦	TARE PLUS WET SOIL		3.631	3.77			<del>                                     </del>	
F	SI SI	TARE PLUS DRY SOIL		3 336	3.459				
Ö		WATER	w w						
WEIGHT	z	TARE		1.502	1.516				
4		DRY SOIL	w ,						
		WATER CONTENT, %	w	16.1	(6 U				
·		PLASTIC LIMIT							
. 1	REI	MARKS -							
_									
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PLATE III-1

## GRAIN SIZE ANALYSIS

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22-60		•			1
Date: 9-20-90			•		Ţ
Project Ho.:	MOUNTAIN ARSO	ENA/			<b>—</b> }
Project: Kocky	COELSB 0022				<b> ૄ</b>
					[
Location of	AASHTO:				
	AASHTO:				ş
USCS:		x:	/		¥,
Liquid Limit:	Plastic Inde 05/7E 2.5', 5', 7.5', 05/12 H2 O & SOIL )	10' 15, 20, 25,	£ 30		(
Remarks: Compo	1517E 210 5 COU	, , , ,			
(SA	VE HO & SOIL)				
	•				
Mechanical and	klysis				
Hydrometer and	klysis				
I uan ama	- chank (	- Mechanical			
		A 98	1 la a h		
	Initial Sample	After	Masn		
Dry Sample and T	PL6=				
Tares	104.2				
Dry Sample Heigh	t=				
			. •		
Cumula	Five Meight Metaling	FA		nı.	%
Tare For Commercia	à formula, a value or	text into the cu	rrent cel	1	sing
	MECHAN	IICAL ANALYSIS	•	1	
U.S. STANDARD S	TEVE				
SIZE(MM)	SIEVE NO.				
3122(1)		SAMPLE WT.% C	<b>+</b> • • • • • • • • • • • • • • • • • • •	% FINER	
76.2 ;	3 INCH	0.0	0.0	100.0 100.0	
38.1	1 1/2 INCH	0.0	0.0	100.0	
19.1	3/4 INCH	0.0	0.0	100.0	
9.52	3/8 INCH	0.0	0.0	100.0	
4.76	NO. 4	0.0	0.0		
PAN		0.0	0.0		
TOTAL		0.9597			
CTOR	2.00	0.0	0.0	100.0	
).10	0.84	1.0	1.0	99.0	
. 20	0.42	4.7	4.5	95.5	
. 40	0.177	16.7	16.0	84.0	
. 80	0.074	42.3	40.6	59.4	
.200	01017	104.2	100.0	0.0	
PAN :		104.4	10010	0.0	

er:

PAN

ue: 104.2

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	miles Salar and and an		5				•	
	9-A			PLASTIC LIN	MIT TESTS 110-2-1906.	BORRO	w#1 -20-90	(A)
PR	DRING NO. 35 BOR	Moun	TAIN	ARSEN	JAL "	ATE9	- 20-90	
ВС	PRING NO. <u>25 BBR</u>	E007		1'-6'	s	AMPLE NO.		
1			1	IQUID LIMIT				
-			1 1	2	3	4	5	6
-	RUN NO. TARE NO.		<del>                                     </del>	9				
-	TARE PLUS WET SOIL		72,135	8.161				
F S	TARE PLUS DRY SOIL		4948	6464				
WEIGHT IN GRAMS	WATER	W	7					
N S	TARE		1.524	1.54				
=	DRY SOIL	w						
	WATER CONTENT, %	w	34.7	34.6				
	NUMBER OF BLOWS		23	20			1	
	WATER CONTENT, W. %	SAVE	HzC	20	30 40	P S F	isymbol from clasticity chart  Med  tou	
		NUMB	ER OF BLOWS					
-			PLASTIC	LIMIT				NATURAL
$\vdash$	RUN NO.		1	.2	3	4	5	WATER
-	TARE NO.		3	4				
	TARE PLUS WET SOIL		3.486	3 053				
WEIGHT N GRAMS	TARE PLUS DRY SOIL		3,253	2 87/				
5 ₹	WATER	w w						
N S	TARE		1,526	1.513				
	DRY SOIL	w ,	- 15	13 77				
	WATER CONTENT, %	w	13.5	13.4				
	PLASTIC LIMIT						<u> </u>	
REI	MARKS							
<u></u>								
TE	CHNICIAN		COMPUTED	BY		CHECKED	Y	
ENG	3 FORM 3838							PLATE III-

## GRAIN SIZE ANALYSIS



Date: 9-20-					
Date: _/_ ~~	-90				•
Project No.1.			. •		
Project: Ro	CKY MOUNTAIN	ARSENAL.		•	
	Sample: 25 BORE	007 /	1-61		
	Iption: BROWN		9		
USCS:					
Liquid Limit:	- 1 // - 1	Index:		•	
Kemarka:	SAIL HEO S	SOIL			
<b>⊠</b>					
Mechanical					
LJ Hydrometer	analysis				
	Data She	et 1 - Mechanic	<b>.</b> 1		
	Initial Sal	mp le	After Wash		
Dry Sample and			DICEL MASH	· ·	
Tare=					
Dry Sample Hei	ight= 113.9				
Calculated -26					
	lative Weight Retains				
			•		
	المسام والمسا				
	MECHA	Sieve Wei	ght   Tare	Cum.	%
	MECHA	NICAL ANALYSIS	ght   Tare	Cum.	2
S. STANDARD SI	MECHA IEVE	NICAL ANALYSIS	ght   Tare	Cum.	%
S. STANDARD SI	MECHA IEVE SIEVE NO.	TONE ANALISIS		•	<b>%</b>
S. STANDARD SI	MECHA IEVE SIEVE NO. 3 INCH	SAMPLE WT.X	6 COARSER	% FINER	2
S. STANDARD SI ZE(MM) 76.2   38.1   19.1	MECHA  IEVE SIEVE NO.  3 INCH 1 1/2 INCH	SAMPLE WT.X	COARSER	•	Z
S. STANDARD SI ZE(MM) 76.2   38.1   19.1   9.52	MECHA  IEVE SIEVE NO.  3 INCH 1 1/2 INCH 3/4 INCH	SAMPLE WT.X 0.0 0.0 0.0	COARSER 0.0 0.0 0.0	% FINER 100.0	2
S. STANDARD SIZE(MM)  76.2   38.1   19.1   9.52   4.76	MECHA  IEVE SIEVE NO.  3 INCH 1 1/2 INCH	SAMPLE WT.X 0.0 0.0 0.0 0.0	COARSER 0.0 0.0 0.0 0.0	% FINER 100.0 100.0	2
S. STANDARD SI ZE(MM) 76.2   38.1   19.1   9.52   4.76   PAN	MECHA SIEVE NO.  3 INCH 1 1/2 INCH 3/4 INCH 3/8 INCH	SAMPLE WT.X 0.0 0.0 0.0 0.0 0.0	6 COARSER 0.0 0.0 0.0 0.0	% FINER 100.0 100.0 100.0	<b>%</b>
S. STANDARD SIZE(MM)  76.2   38.1   19.1   9.52   4.76   PAN OTAL	MECHA SIEVE NO.  3 INCH 1 1/2 INCH 3/4 INCH 3/8 INCH	SAMPLE WT.X 0.0 0.0 0.0 0.0 0.0 0.0	COARSER 0.0 0.0 0.0 0.0	% FINER 100.0 100.0 100.0 100.0	<b>%</b>
S. STANDARD SIZE(MM)  76.2 38.1 19.1 9.52 4.76 PAN OTAL	MECHA SIEVE NO.  3 INCH 1 1/2 INCH 3/4 INCH 3/8 INCH	SAMPLE WT.X 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0	6 COARSER 0.0 0.0 0.0 0.0	% FINER 100.0 100.0 100.0 100.0	<b>%</b>
S. STANDARD SIZE(MM)  76.2 38.1 19.1 9.52 4.76 PAN OTAL TOR	MECHA SIEVE NO.  3 INCH 1 1/2 INCH 3/4 INCH 3/8 INCH	SAMPLE WT.X 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0	COARSER 0.0 0.0 0.0 0.0 0.0 0.0	% FINER 100.0 100.0 100.0 100.0	2
S. STANDARD SIZE (MM)  76.2 38.1 19.1 9.52 4.76 PAN TOTAL TOR 10 20	MECHA SIEVE NO.  3 INCH 1 1/2 INCH 3/4 INCH 3/8 INCH NO. 4	SAMPLE WT.X  0.0  0.0  0.0  0.0  0.0  0.0  0.0	COARSER 0.0 0.0 0.0 0.0 0.0 0.0	% FINER 100.0 100.0 100.0 100.0	<b>%</b>
S. STANDARD SIZE (MM)  76.2 38.1 19.1 9.52 4.76 PAN TOTAL CTOR 10 20 40	MECHA SIEVE NO.  3 INCH 1 1/2 INCH 3/4 INCH 3/8 INCH NO. 4	SAMPLE WT.X 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0	COARSER 0.0 0.0 0.0 0.0 0.0 0.0	% FINER 100.0 100.0 100.0 100.0 100.0	2
S. STANDARD SIZE (MM)  76.2 38.1 19.1 9.52 4.76 PAN TOTAL CTOR 10 20 40 80	MECHA  SIEVE NO.  3 INCH 1 1/2 INCH 3/4 INCH 3/8 INCH NO. 4  2.00 0.84	SAMPLE WT.X  0.0  0.0  0.0  0.0  0.0  0.0  0.0	COARSER 0.0 0.0 0.0 0.0 0.0 0.0 0.0	% FINER 100.0 100.0 100.0 100.0 100.0	<b>%</b>
S. STANDARD SIZE (MM)  76.2 38.1 19.1 9.52 4.76 PAN  TOTAL  CTOR 10 20 40 80 200	MECHA  SIEVE NO.  3 INCH 1 1/2 INCH 3/4 INCH 3/8 INCH NO. 4  2.00 0.84 0.42	SAMPLE WT.X  0.0  0.0  0.0  0.0  0.0  0.0  0.0	COARSER 0.0 0.0 0.0 0.0 0.0 0.0 0.1 0.9 5.4 13.4 20.5	% FINER 100.0 100.0 100.0 100.0 100.0	<b>%</b>
S. STANDARD SIZE (MM)  76.2 38.1 19.1 9.52 4.76 PAN TOTAL CTOR 10 20 40 80	MECHA  SIEVE NO.  3 INCH 1 1/2 INCH 3/4 INCH 3/8 INCH NO. 4  2.00 0.84 0.42 0.177	SAMPLE WT.X  0.0  0.0  0.0  0.0  0.0  0.0  0.0	COARSER 0.0 0.0 0.0 0.0 0.0 0.0 0.0	% FINER 100.0 100.0 100.0 100.0 100.0	2

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Loc: r23c5

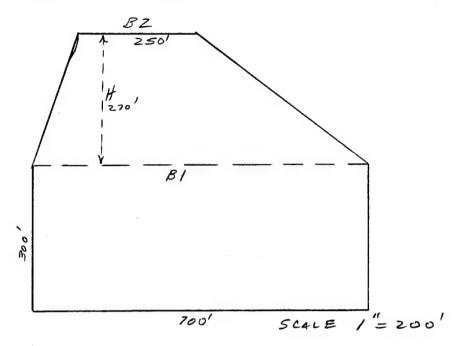
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MAHA DISTRICT				OF ENGINEERS
ROJECT	E hadselvale h	4 12 1		of 2 to
				DATE 9/4/90
	have been standards. The		CHKD. BY	DATE
SOUTH WALL				
AVG. WATER L	EVEL OUT	SIDE V		FO
AUGT WATER	LEVEL INS	DEW	ALL = 524	17
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OMAHA DISTRICT COMPUTATION SHEET	CORPS	OF ENGINEERS
PROJECT PMA LIME SETTLING BASINS	SHEET NO. /	OF. 2
ITEM CALCULATION OF INITIAL WATER	BY JMZ	DATE 5/18/90
		DATE

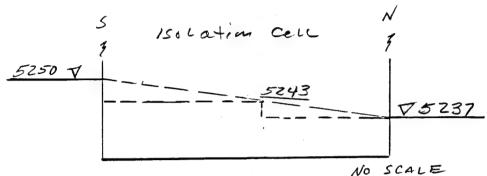
WITHIN ISOLATION CELL



AKEA TRAPAZOID = 
$$\frac{B1+B2}{2} \times H$$
  
=  $\frac{700+250}{2} \times 270'$   
=  $128,250 \text{ } H^2$ 

TOTAL AREA OF CELL = 128, 250 FT + 210,000 A2
= 338, 250 Ft2

OMAHA DISTRICT	COMPUTATION SHEET	CORPS	OF ENGINEERS
PROJECT RMA LIME.	SETTLING BASINS	SHEET NO. 2	0F 2
ITEM CALCULATION		BY JMZ	DATE 5/18/90
WATER LEVEL "	NITHIN CELL AFTER	CHKD. BY	DATE



Estimated porosity = 35%

= 134,663 Ft<sup>3</sup>

EXCESS VOL VOIDS RECT-TRAP = 122,587

TOTAL VOL VOIDS PER 1'DEPTH IN CELL = 0.35 x (338,250) (1) = 118,388 ft3

TOTAL RISE ABOVE EL 5243

= 1.04 Ft ROUND TO 1.0'

EL STABILIZED WL IN CELL = 5243 +1 = 5244

OMAHA DISTRICT COMPUTATIO	N SHEET CORPS OF ENGINEERS	
PROJECT RMA- Lime Settling Basins	SHEET NO. / OF 8	
ITEM Ground Water Infiltration throw	7h BY JMC DATE 5-21-90	0
Slurry Wall - Volume Calculat		

Formula for Volume Colenlations Q = K I A

Q = volume of seepage through benean to slurry well

K = hydroulic conductivity of slurry wall

I = gradient

A = area of sturry wall

OMAHA DISTRICT COMPUTATION SHEET	CORPS	OF ENGINEERS
PROJECT RMA Lime Settling Basins	SHEET NO. 2	OF 8
ITEM Ground Water Infiltration through	BY_IMC	DATE 5-18-90
Slurry Walls - Volume Calculations	CHKD. BY	DATE

1"=10"

South Wall

waterlerd 5250 \\
outside unil

Avg. Topof Bedrock

V 5234 water level Inside cell

$$P = K = H$$

$$K = .00028 ft/day = 10^{-7} cm/sec$$

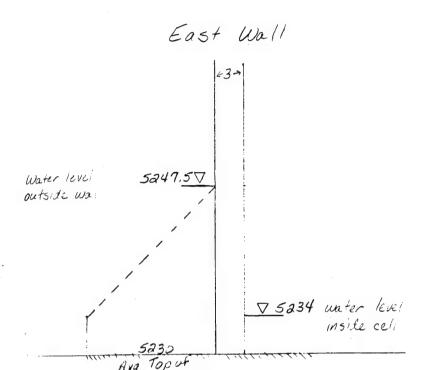
$$I = 13 \div 3 = 2.17$$

$$A = 13 \times 100 = 9100 ft^{2}$$

 $Q_s = .00028 \times 2.17 \times 9100 = 5.53 \cdot ft^3/day$ 

OMAHA DISTRICT	COMPUTATION SHEET	CORPS	OF ENGINEERS
PROJECT RMA-Lime	Settling Bosins	SHEET NO. 3	3 OF 8
ITEM Ground Water	Infiltration through	BY IMC	DATE 5-18-90
Slurry Walls -	Volume Calculations	CHKD. BY	DATE

1=101



$$Q = KIA$$

$$K = .00028 \text{ ft/day} = 10^{-7} \text{ cm/scc}$$

$$I = 13.5 \div 3 = 2.25$$

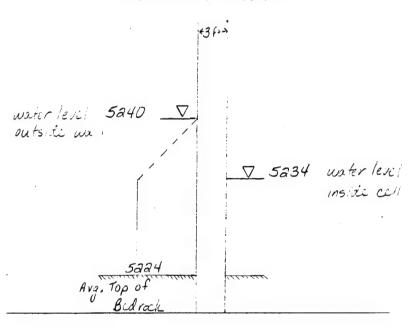
$$A = 17.5 \times 300 = 5250 \text{ ft}^2$$

Q= .00028 x 2.25 x 5250 = 3.31 ft3/day

OMAHA DISTRICT	COMPUTATION SHEET	CORPS	OF ENGINEERS
PROJECT RMA - Lime Settlin	a Bosins	SHEET NO. 4	0F 8
ITEM Ground Water Infiltrati		BY IMC	DATE 5-18-90
Slurry Wall - Volu	ime Calexlations	CHKD. BY	DATE

1"=101

North East Wall

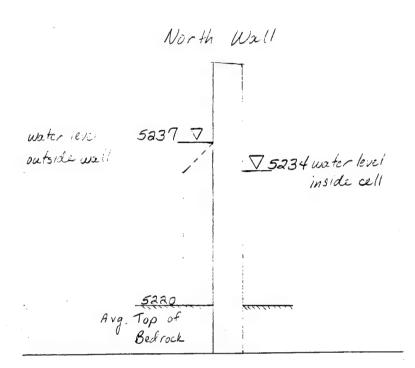


$$Q = KIA$$
 $K = .00028 \text{ ft}/day = 10^{-7} \text{ cm}/322$ 
 $I = \frac{6}{2} \div 3 = 1$ 
 $A = 16. \times 460 = 7360 \text{ ft}^2$ 

QNE= ,00028 X 1 x 7360 = 2,06ft3/day

OMAHA DISTRICT	COMPUTATION SHEET	CORPS	OF ENGINEERS
PROJECT RMA - Lime Se	Hling Bosins	SHEET NO. 5	OF 8
ITEM Ground Water Ins	/ 1 / 2 / 2 / 2 / 2 / 2 / 2 / 2 / 2 / 2	BY JMC	DATE 5-18-90
Slurry Wall -	Volume Calculations	CHKD. BY	DATE

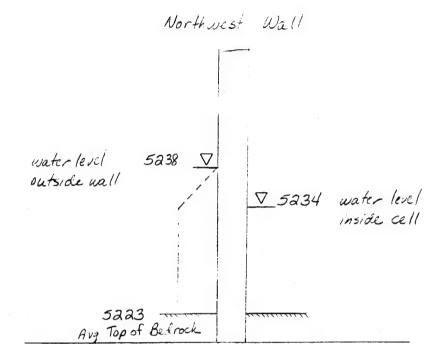
1=10'



$$Q = KIA$$
 $K = .000088 \text{ ft } |day = 10^{-7} \text{ cm} | sec$ 
 $I = \frac{3}{4} \div 3 = 0.5$ 
 $A = 17 \times 250 = 4250 \text{ ft}^2$ 
 $Q_N = .00028 \times .5 \times 4250 = .595 \text{ ft}^3 | day$ 

OMAHA DISTRICT CO	MPUTATION SHEET	CORPS	OF ENGINEERS
PROJECT RMA - Lime Settling Bo	sins SHE	ET.NO. 6	OF 8
ITEM Ground Water Infiltration	n through BY	JMC	DATE 5-18-90
Slarry Walls - Volum	e Calculations CHK	CD. BY	DATE

1"=10"



$$Q = KIA$$

$$K = .00028 ft | day = 10^{-7} cm | sec$$

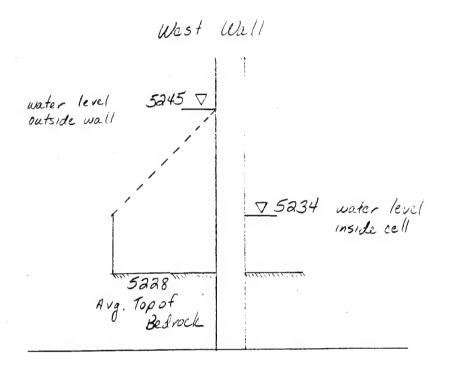
$$I = \frac{4}{a} \div 3 = .66$$

$$A = 15 \times 290 = 4350 ft^{2}$$

$$Q_{NW} = .00028 \times 0.66 \times 4350 = 0.812 ft^{3} | day$$

OMAHA DISTRICT	COMPUTATION SHEET	CORPS	OF ENGINEERS
PROJECT RMA - Lime	Settling Basins	SHEET NO. 7	OF 8
	Infiltration through	BY JMC	DATE 5-18-90
	Volume Calculations	CHKD. BY	DATE

1"=101



$$Q = KIA$$

$$K = .00028 \text{ ft}/3ay = 10^{-7} \text{ cms/sec}$$

$$I = 4 \div 3 = 1.83$$

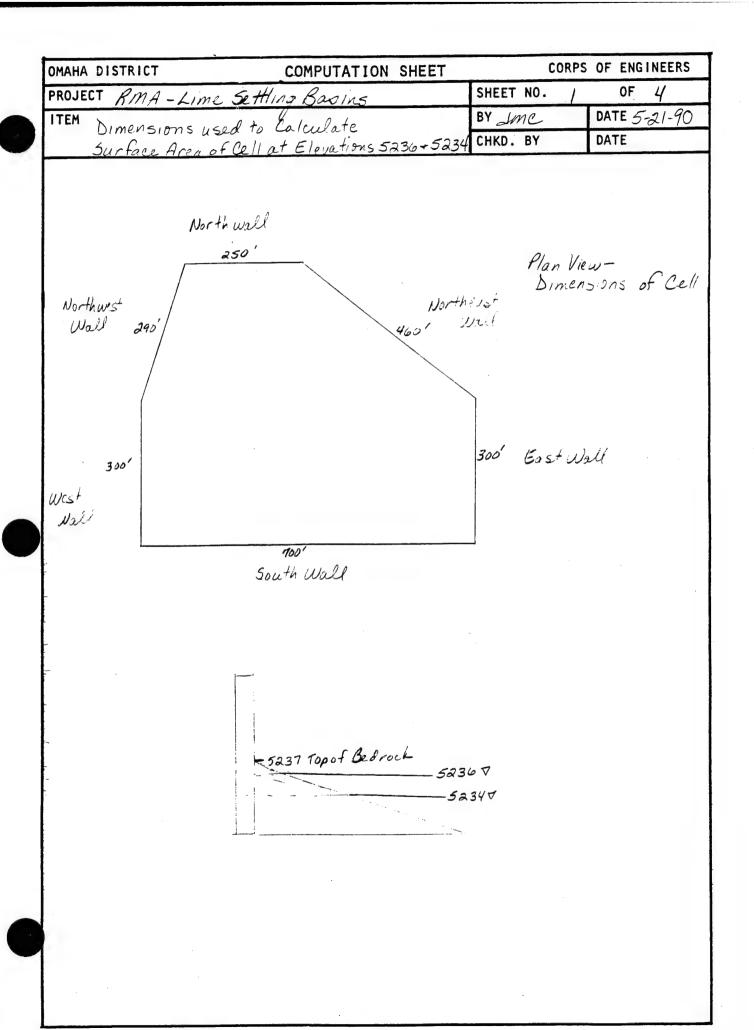
$$A = 17 \times 300 = 5100 \text{ ft}^2$$

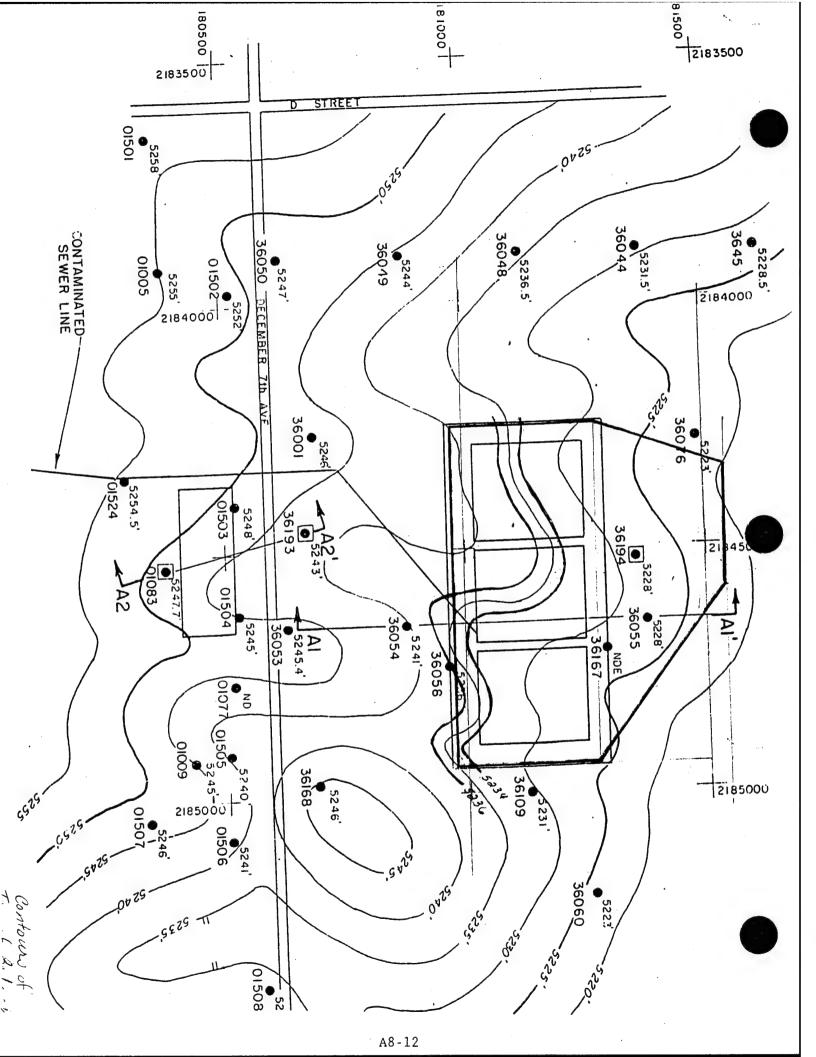
$$Q_w = .00028 \times 5100 \times 1.83 = 2.62 \text{ ft}^3/\text{day}$$

OMAHA DISTRICT	COMPUTATION SHEET	CORPS	OF ENGINEERS
PROJECT RMA-Lime	Settling Basins	SHEET NO. 8	OF 8
	Infiltration through	BY JMC	DATE 5-21-90
Slurry Wall -	Volume Concentrations	CHKD. BY	DATE

$$\begin{aligned}
\mathcal{P}_{\text{TOT}} &= \mathcal{P}_{S} + \mathcal{Q}_{E} + \mathcal{Q}_{NE} + \mathcal{Q}_{N} + \mathcal{Q}_{NW} + \mathcal{Q}_{W} \\
\mathcal{P}_{S} &= 5.53 \text{ ft}^{3}/\text{day} \\
\mathcal{Q}_{E} &= 3.31 \text{ ft}^{3}/\text{day} \\
\mathcal{Q}_{NE} &= 2.06 \text{ ft}^{3}/\text{day} \\
\mathcal{Q}_{N} &= 0.60 \text{ ft}^{3}/\text{day} \\
\mathcal{Q}_{N} &= 0.81 \text{ ft}^{3}/\text{day} \\
\mathcal{Q}_{W} &= 2.62 \text{ ft}^{3}/\text{day} \\
\mathcal{Q}_{TOT} &= 14.93 \text{ ft}^{3}/\text{day}
\end{aligned}$$

14.93 ft 3/day = 0.42 m3/day = 111.68 gal/day = .08 gal/min





PROJECT RIMA -LIME SETTING BASINS. SHEET NO.  ITEM SURFACE AREA OF CELL AT 5236 \$ 5234 CHKD. BY	CORPS OF ENGINEE	RS
ITEM SAGALE MER OF CELL AT 5236 \$ 5234 BY LIME	2 OF 4	
SURFACE AMEH OF CELL AT SCORE 3 COY	DATE 5/21/	19.
(SCALE FACTOR- ZOON ZOO- 40,000 CHKD. BY	DATE	

E1.5234=6.35° x 40,000 = 174,000° E1.5236=7.40° x 40,000 = 296,000°

OMAHA DISTRICT COMPUTATION SHE	ET CORPS	OF ENGINEERS
PROJECT RMA - LIME SETTLING BASINS	SHEET NO. 3	0F <i>4</i>
ITEM Volume Calculations from surface areas	BY JMC	DATE 5-21-90
at Eleva+10ms 5236 & 5234	CHKD. BY	DATE

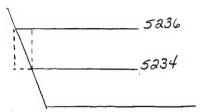
At Elevation 5234  $\rightarrow$  Surface Area = length x width = 174,000 ft<sup>2</sup> Volume = 174,000 ft<sup>2</sup> x 2 ft = 348,000 ft<sup>3</sup>

Pore Volume = 348,000 ft 3 x 35 % = 121,800 ft 3

At Elevation 5236 -> Surface Area = length x width • 296,000 ft<sup>2</sup> Volume = 296,000 ft<sup>2</sup> x 2 ft = 592,000 ft<sup>3</sup>

Pore Volume = 592,000 ft 3 x 35° / = 207200 ft3

OMAHA DISTRICT	COMPUTATION SHEET	CORPS	OF ENGINEERS
PROJECT RMA-Lime		SHEET NO. 4	0F <i>4</i>
ITEM Average Volume	between 5236 + 5234 Elevations	BY JMC	DATE 5-21-90
U			DATE

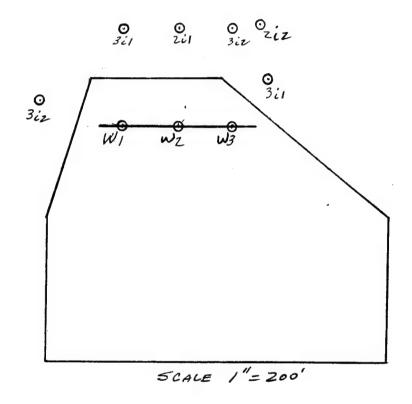


Volume at 5236'= 296,000 ft² x 2 ft = 592,000 ft³
Volume at 5234'= 174,000 ft² x 2 ft = 348,000 ft³

Average Volume = 592,000  $\frac{+348,000}{940,000} \div 2 = 470,000 \text{ ft}^3$ 

Average Pore Volume = 470,000 ft 3 x 35 % = 164,500 ft 3

OMAHA DISTRICT COMPUTATION SHEET	CORPS	OF ENGINEERS
PROJECT LIME SETTLING BASINS	SHEET NO. /	0F 3
ITEM ANALYSIS OF G. W. WITHDRAWAL	BY JMZ	DATE
BY WELLS.	CHKD. BY	DATE



$$Q = \frac{\int \int K (H^2 - L^2)}{\ln_e R}$$

Where 
$$\Phi = Pumping RATE FF^3/Day$$
 $K = HyD, COND. FT/Day$ 
 $H = SATURATED THICKNESS FT$ 
 $h_w = HEIGHT OF WATER IN WELL FT$ 
 $R = ASSUMED RADIUS OF INFLUENCE FT$ 
 $T = RADIUS OF WELL FT$ 

OMAHA DISTRICT COMPUTAT	ION SHEET CORPS OF ENGINEERS
PROJECT LSB	SHEET NO. 2 OF 3
ITEM ANAL. GW WITHDRAWAL	BY JM2 DATE
BY WELLS	CHKD. BY DATE

$$H = 12.0'$$

$$h_{0} = 12.0 - [(12.0) \times 60\%)] = 4.8$$

$$Q = (3.14)(0.283)(12.0^{2} - 4.8^{2})$$

$$\lim_{\epsilon} \frac{500}{0.5}$$

Q=15.6 Ft 3/DAY = 0.08 gpm

THIS VOLUME IS TOO SMALL TO PUMP EVEN
DISREGARDING BOUNDARY AND INTERFERENCE EFFECTS

CALCULATION OF THEORETICAL DRAWDOWN FOR WELL #3 INCLUDING BOUNDARY AND INTERFERENCE EFFECTS

FOR BOUNDARY EFFECT NE OF WY FOR MAGE WELL W3: AT V= 120'

$$h_{\omega_{3i}} = \sqrt{144 - (17.6) \ln_e \frac{500}{120}} = \sqrt{144 - 25.1} = 10.9'$$
 $\therefore DD DUE TO NE BOUNDARY = 12.0 - 10.9' = 1.1'$ 

OMAHA DISTRICT C	OMPUTATION SHEET	CORPS	OF ENGINEERS
PROJECT LSB		SHEET NO. 3	0F <i>3</i>
ITEM ANAL G.W. WITHO	RAWAL	BY JMZ	DATE
BY WELLS	***************************************	CHKD. BY	DATE

FOR BOUNDARY EFFECT N. OF W3 FOR IMAGE WELL W312 AT 1=200'

FOR WELL INTERFERENE FROM WY AT V=112.5

INTERFERENCE = 12.0-10.8 = 1.2'

FORWELL INTERFERENCE FROM W, AT Y = 225'

, DD DUE TO W, INTERFERENCE = 12.0-11.4 = 0.6

AVAILABLE DD /2.0' C CALCULATED DD 13.5'

. NOT SUFFICIENT AVAILABLE DD TO PRODUCE

0.08 gpm

OMAHA DISTRICT COMPUTATIO	N SHEET CORPS OF ENGINEERS
PROJECT LSB	SHEET NO. / OF /
ITEM HYDRAULIC CONDUCTIVI	BY JNZ DATE
DETERMINATION	CHKD. BY DATE

FROM ELUG TESTS

HOLE #34 AVE 3.4 × 10 4 FHMIN

11 35 " 2.3 × 10 4 "

5.7 × 10 4 "

ANE of AVE 5.7 × 10 4 FT/MIN = 2.8 × 10 4 FT/MIN

2.8 × 10 4 FT/MIN = 2.8 × 10 4 FT/MIN = 1.8 × 10 4 FT/MIN

2.8 × 10 4 FT/MIN × 12 in/Ft × 2.54 cm/m: 60 see/min = 1.4 × 10 4 cm/see

For Conversative approach use 1.0 × 10 4

1.0 × 10 4 cm/see: 2.54 cm/m: 12 m/Ft × 60 see/min

× 1440 min/day = 0.283 FT/day

OMAHA DISTRICT	COMPUTATION	SHEET	CORPS	OF ENGINEERS
PROJECT LIME SETTLIN	BASINS		SHEET NO. /	0F <del>/</del>
ITEM CALCULATION		Crimi	BY TMZ	DATE
HORIZONAL DRAIN	/	7 , 5 , 0 ,	CHKD. BY	DATE

1. Utilizing Ibrahim and Brutsaert (1965)
equations as discussed by freeze and
Cherry (1979). See griphs and diagrams
by freeze and Cherry as reproduced in
this apprendix. Construction of the graph
for arrange flows from the drain Utilize these
graphs and dragram, and a quations shown
in the appendix.

For a horizontal drain hocated at an average depth below the water table of 11 feet, a Length of 325 Feet, the Following lequations are used.

and 
$$y = \frac{5yL}{KH^2}g$$

when y = dimensionless discharge<math>g = rate of Flow from one side of thedrain at time t.

Solving For &

$$g = \frac{SKH^2}{5gL}$$

OMAHA DISTRICT	COMPUTATION SHEET CORPS OF ENGINEERS		S OF ENGINEERS
PROJECT LSB		SHEET NO. 2	_ OF 4
ITEM CALCULAtion	of Flow From horiz.	BY Juz	DATE
drain	7 7 7 7 7 7 7 7 7 7 7 7 7 7 7 7 7 7 7 7	CHKD. BY	DATE

From equation 
$$C = \frac{KH}{5gL^2} + For North 5ide$$

Let  $C = \frac{KH}{5gL^2} + For K = 0.283 \text{ Ft/day}$ .

Then  $T = Ct$ 
 $C = \frac{KH}{5gL^2} + \frac{1}{5gL^2} + \frac{1$ 

Determine values of C and f for various time intervals  $C = \frac{(0.283)(11)}{(0.2)(100)^2} = 0.8016$ 

$$T = (0.0016)(10) = 0.016$$
  $Y = 4.9 (est)$   
 $T = (0.0016)(20) = 0.032$   $Y = 3.0 (est)$   
 $T = (0.0016)(100) = 0.16$   $Y = 0.85$ 

$$C = (0.0016)(500) = 0.80$$
  $t = 0.27$ 

$$T = (0.0016)(1500) = 2.4$$
  $y = 0.076$   
 $T = (0.0016)(2000) = 3.2$   $y = 0.047$ 

$$g = \frac{3kH^2}{5gL}$$
 Let  $C = \frac{kH^2}{5gL} = \frac{(0.283)(11)^2}{(0.2)(100)} = 1.7$ 

$$q = (4.9)(1.7) = 8.33 \text{ Ft}^3/\text{day}/\text{Ft}$$
 10 days  
 $q = (3.0)(1.7) = 5.10 \text{ " " } 20 \text{ "}$   
 $q = (0.85)(1.7) = 1.45 \text{ " " } 100 \text{ "}$ 

OMAHA DISTRICT	COMPUTATION SHEET	CORPS	OF ENGINEERS
PROJECT LSB		SHEET NO. 3	OF 4
Horizonatal dra	E Elan Fra	BY JMZ	DATE
Horizon etal dra	in	CHKD. BY	DATE

$$q = (0.56)(1.7) = 0.95 Ft^{3}/day/Ft$$
 Zoo days  
 $q = (0.27)(1.7) = 0.46$  " 500 "  
 $q = (0.13)(1.7) = 0.02$  " 1000 "  
 $q = (0.076)(1.7) = 0.13$  " 1500 "  
 $q = (0.047)(1.7) = 0.08$  " 2000 "

Time to veach el 5234 at North wall.

$$H = 5237 - 5225 = 12'$$
  
 $h = 5234 - 5225 = 9'$ 

$$\frac{4}{1} = \frac{9}{12} = 0.75$$

$$\frac{x}{L} = 1$$
 2 from graph = 0.39

$$t = \frac{CSyL^2}{KH} = \frac{(0.59)(0.2)(100)^2}{(0.283)(12)} = 230 \text{ days}$$

Ave FLOW For 230 days (from graph) North side

10 12.0 (
$$\epsilon$$
- $\tau$ ) 120
10 6.7 67
80 3.3 264
100 1.2 120
30 0.9 27
230 598 Ft/Ft • F drain

$$\frac{598}{230} = \frac{2.6}{6} \frac{ft^3}{day/ft} = \frac{4}{6} \frac{4}{6} \frac{4}{6} \frac{4}{6} = \frac$$

OMAHA DISTRICT COMPUTATION SHEET	CORPS	OF ENGINEERS
PROJECT LSB	SHEET NO. 4	0F 4
ITEM Calculation of FLOW from	BY JUZ	DATE
Horiz drain	CHKD. BY	DATE

For total average Flow From the drain multiply Flow From north sid by 2 and Length Harain.

2.6 ft 3/day / ft x 2 x 3 z 5 ft = 1690 ft 3/day.

This is equivalent to:

1690 Ft /day x 7.48 gal/ft - 1440 min/day = 8.8 gpm

Since boundary effects are not considered at the ends of the drain, and equations model Flow from a free face, the flow rate from the drain will be Less than 8.8 gpm. Recommend initial pumping rate from extraction system be 5.0 gpm.

Instal time required to reach elev 5234 at North wall journing at 5gpm:

Volume to be pumpsed = 1690 FF /day x 230 days

230 dags @ 5g.nm = 221,000 Ft 3 (rounded) 396 days @ 2.2 gpm = 167,700 626 388,700

Time to reach elev 5234 @ North wall.

626 days/gr = 1.7 years.

Total volume remaining in cell above elsu 5234

= 164,500 between el 5234 \$ 5236

+ 947, 104 between el 5236\$ 5244

- 388,700 amount drained in 1,7 years

Total time to drain at ave, 0.36 Ft /day /ft x 325ft.

 $=\frac{722,904}{117}=6179 \text{ days}-\frac{6179}{365}=16.9 2 17 \text{ years}.$ 

OMAHA DISTRICT	COMPUTATION SHEET	C	ORPS (	OF ENGI	NEERS
PROJECT LSB		SHEET NO.	/	OF	/
ITEM EQUATIONS, 6		BY	1	DATE	
FROM FREEZE	CALCULATIONS AND CHERRY (1979)	CHKD. BY	1	DATE	

495

## Groundwater and Geotechnical Problems / Ch. 10

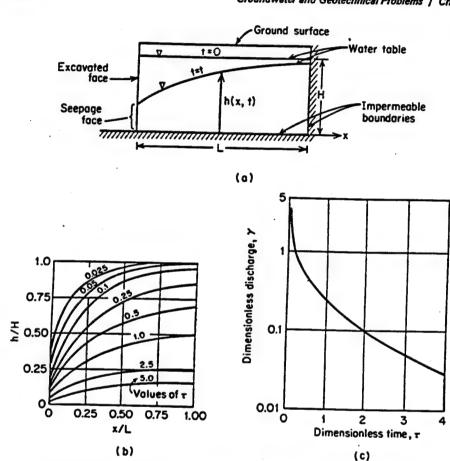


Figure 10.18 Prediction of groundwater inflows into an excavation (after Ibrahim and Brutsaert, 1965).

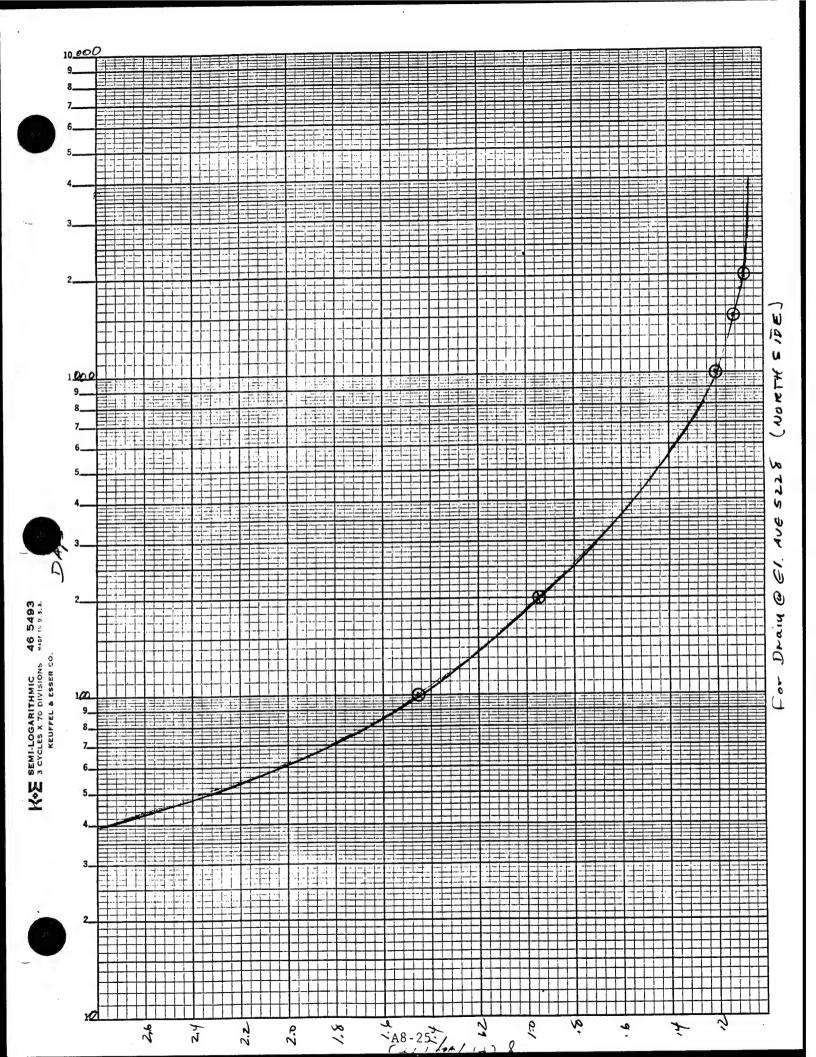
Figure 10.18(b) shows the transient response of the water table, plotted as dimensionless drawdown, h/H, versus dimensionless distance, x/L. The parameter  $\tau$  is a dimensionless time given by

$$\tau = \frac{KH}{S_{\tau}L^2}t\tag{10.19}$$

where H and L are defined by Figure 10.18(a), K and S, are the hydraulic conductivity and specific yield of the aquifer, and t is time. In Figure 10.18(c), the dimensionless discharge  $\gamma$ , defined by

$$\gamma = \frac{S_r L}{KH^2} q \tag{10.20}$$

is plotted against  $\tau$ . The outflow q=q(t) is the rate of flow (with dimensions  $L^3/T$ ) into the excavation from the seepage face, per unit length of excavated face per-



OMAHA DISTRICT	COMPUTATION	SHEET		CORP	S OF E	NG I	VEERS
PROJECT LSB			SHEET	NO. /	0	F	1
ITEM Calculated time Stabilized (non-pumpin	to revelu	Leus C	BY	TMZ	DATE		
within the cell	9, 1122		CHKD.	BY	DATE		

$$Q = KIA$$
  
 $K = 1 \times 10^{-4} \text{ cm/sec} = 0.283 \text{ ft/day}.$   
 $I = 6 - 9$ 

a) 
$$Q = (0.283)(\frac{6}{310})(9800) = 55.5 ft^{3}/day$$

$$t = \sqrt{Q} = \frac{22,444}{55.5} = 404 days$$

b) 
$$\varphi = (0.283)(\frac{5}{200})(9800) = 46 ft^3/day$$

c) 
$$Q = (0.283)(\frac{4}{300})(9800) = 37 ft^3/deg$$

d) 
$$Q = (0.283) \left(\frac{3}{500}\right) \left(9800\right) = 27.7 \frac{4^3}{49}$$
  
 $E = \frac{22,444}{27.7} = 810 \text{ days}$ 

e) 
$$Q = (0.283)(\frac{2}{300})(9800) = 18.5 Riphy$$
  
 $t = \frac{22,444}{18.5} = 1,213 days$ 

F) 
$$Q = (0.283)(\frac{1}{3.0})(9500) = 9.2 \text{ ft}^3/\text{day}$$
  
 $t = 22,444$   
 $9.2$ 

$$\frac{5965}{265} = 16.3 \text{ years}.$$

$$\frac{2,440}{5,961} \text{ day}$$

OMAHA DISTRICT	COMPUTATION SHEET	CORPS	OF ENGINEERS
PROJECT LSB		SHEET NO. /	0F
ITEM SAND FILTER	2 DESIGN FOR	BY JM2	DATE
DEAIN EM 1110	-2-1901	CHKD. BY	DATE

Carculated Filter FM= Filter Material Ps= Protected Soil

Min 
$$\frac{D_{50FA}}{D_{50PS}} - \frac{0.5}{O_{D3}} = 17$$
  $= 25$ 

Permeab, Lity

SLOT SIZE FOR THE DRAIN

0.5 mm is equivalent to a # 20 560T= 0.020"

OMAHA DISTRICT	COMPUTATION SHEET	CORP	S OF ENGINEERS
PROJECT LSB		SHEET NO. 2	_ OF
ITEM SAND FILTER	2 Design For	BY JMZ	DATE
DRAIN EM 1110	-2-1901	CHKD. BY	DATE

ASTM C-33 FINE AGGREGATE FOR CONCRETE

PIPING

Max 
$$\frac{D_{15R4}}{D_{85}PS} = \frac{0.38}{0.42} = 0.9 < 5$$

Permeability

Max 
$$\frac{D_{15F4}}{D_{15ps}} = \frac{0.38}{0.09} = 9.5 > 5$$

$$\frac{M_{14}}{D_{15}P_{5}} = \frac{0.17}{0.0005} = 34 > 5$$

SLOT SIZE

0.5 mm 15 equivalent to a # 20 scot = 0.020"

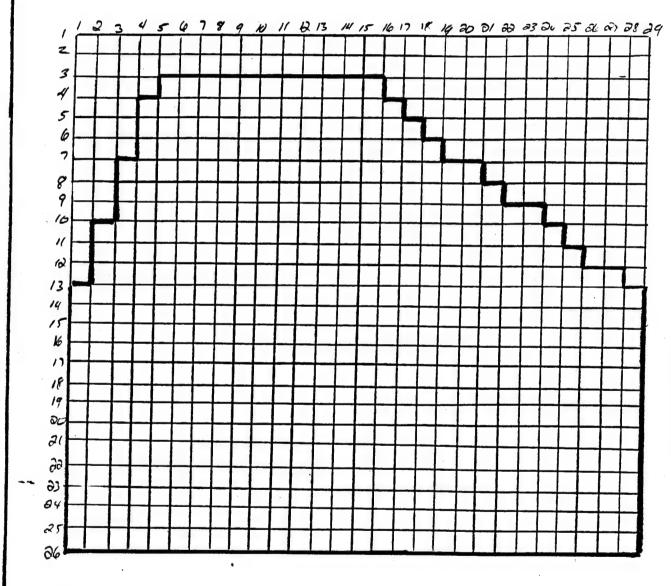
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GRÁDATION	SILTY	SILTY	7	SILTY:	SANDY L		COARSE	CDAVE	50																			/		U.S. STANDARD SIEVE OPENING IN INCHES
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1990 J	LS835	CXTACTION	7 / 1	a BASINS	W HRSENAL				0.005	/	1	/																		
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OMAHA DISTRICT COMPUTATION SHEET		OF ENGINEERS
PROJECT RMA -LIME SETTLING BASINS	SHEET NO. /	OF /
Flow DIAGRAM AFTER ISOLATION CELL	BY IMC	DATE 8-10-90
	CHKD. BY	DATE
5255 5255	EQUIPOTE FLOW	ENTIAL LINES LINES

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MRO Form 1550, 1 DEC 83

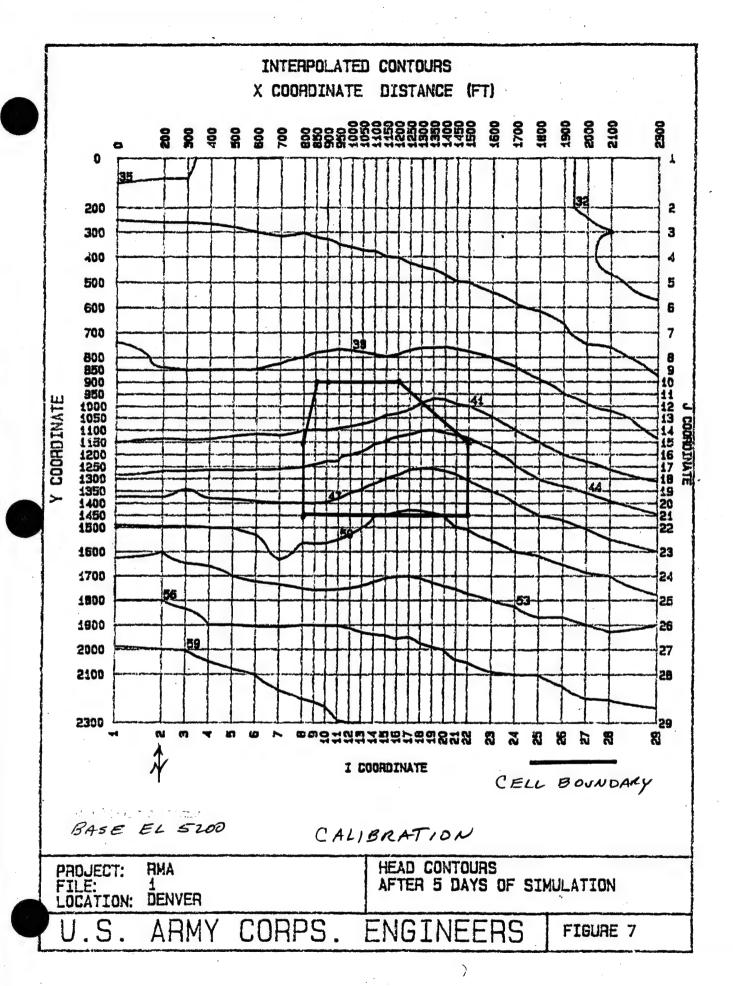
OMAHA DISTRICT	. Co	OMPUTATION SHEET	CORPS	OF ENGINEERS
PROJECT RMA	Lime Settling	Rasin	SHEET NO. 2	of a
ITEM	V	ζ	BY John HACHEY	DATE 10 - 11-90
Finite Differen	re Grid Slurry	Woll System	CHKD. BY	DATE

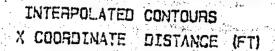


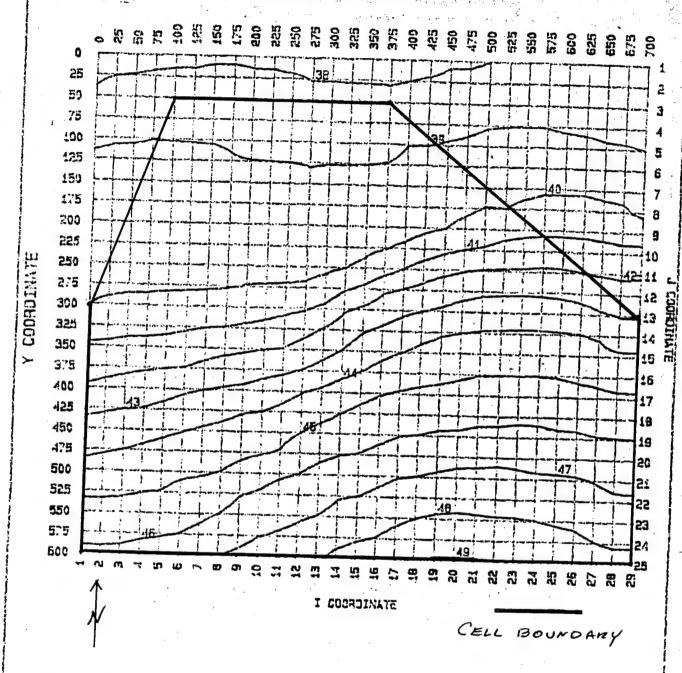
scale.

- Slurry wall boundary conditions modeled as no flow

Bold line designates boundary - north model boundary modeled of slurry wall as constant head





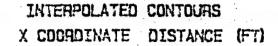


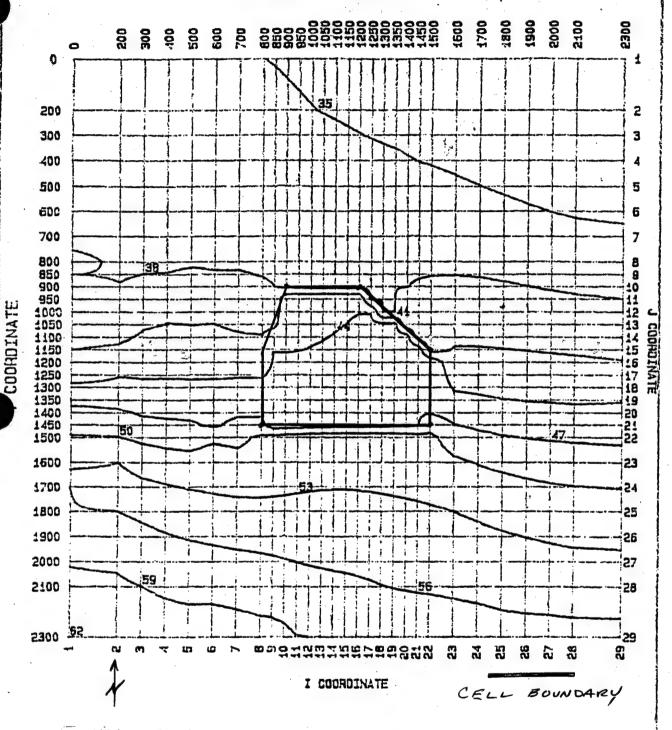
BASE EL SLOD

CALIBRATION

PROJECT: AMA CELL HEAD CONTOURS AFTER 5 DAYS OF SIMULATION

U.S. ARMY CORPS. ENGINEERS FIGURE 2



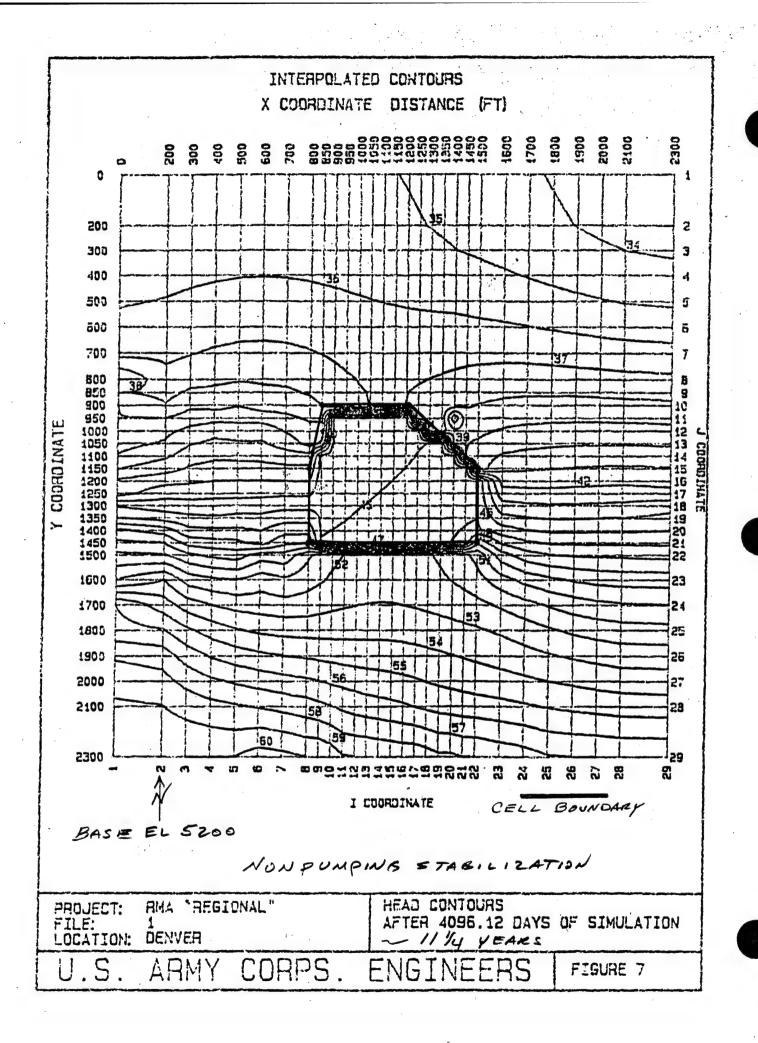


BASE EL 5200 NONPUMPING EPUALIZATION

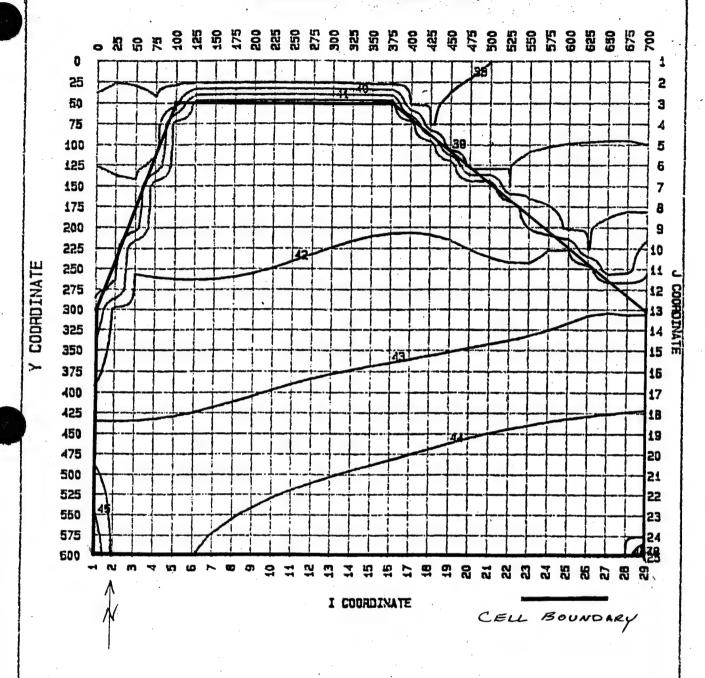
PROJECT: rma

ILE:
CCATION: denver

U.S. ARMY CORPS. ENGINEERS FIGURE 3



# INTERPOLATED CONTOURS X COORDINATE DISTANCE (FT)



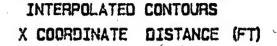
BASE EL. 5200

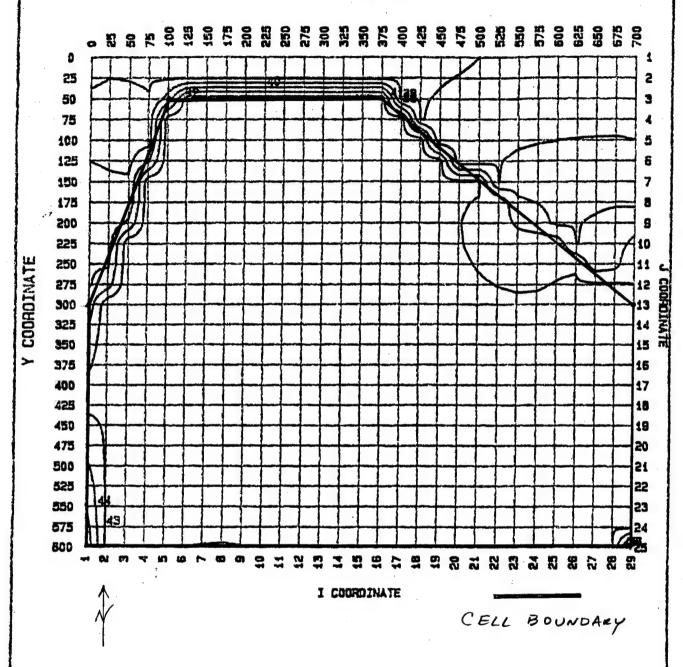
NONPUMPING EQUALIZATION

PROJECT: RMA CELL FILE: C1 LOCATION: DENVER HEAD CONTOURS
AFTER 2359.907 DAYS OF SIMULATION
261/2 YEARS

U.S. ARMY CORPS. ENGINEERS

FIGURE 2





BASE EL 5200

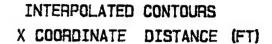
NON PUMPING STABILIZATION

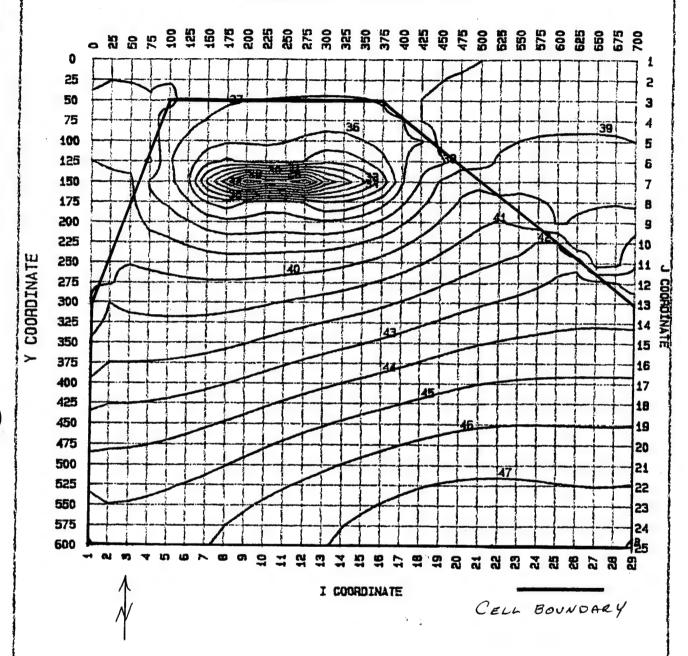
PROJECT: RMA CELL FILE: C1 LOCATION: DENVER HEAD CONTOURS

AFTER 7095.295 DAYS OF SIMULATION

~ 191/2 YEARS

U.S. ARMY CORPS. ENGINEERS FIGURE 5





BASE EL. 5200

48 - 1-2

DRAIN SIMULATION 10 PUMPING WELLS 0.10 SPM EACH = 1.0 SPM TOTAL

PROJECT: RMA CELL C1 LOCATION: DENVER

HEAD CONTOURS AFTER 295.9797 DAYS OF SIMULATION

U.S. ARMY CORPS. ENGINEERS FIGURE 5

OMAHA DISTRICT COMPUTATION SHEET	CORPS	OF ENGINEERS
PROJECT RMA-Lime Settling Basins	SHEET NO. )	0F 3
	BY IMC	DATE 5-24-90
(Denver Fm)	CHKD. BY	DATE

Data obtained from boring log for monitoring well 36109

DEPTH TO A SAND -> 61.6 ft.

THICKNESS OF OVERBURDEN > -27.1 ft.

THICKINESS OF CLAYSTONE -> 34.5 ft.

GRADIENT OF CLAYSTONE:

5243 ft. Elevation of top of A Sand (head)
-5234 ft. Elevation of head to be maintained in cell

9 ft.

9ft. = .26 = Hydraulic Gradient of Claystone 34.5ft.

OMAHA DISTRICT	COMPUTATION SHEET	CORPS	OF ENGINEERS
PROJECT RMA-Lime Settling	ng Baxins	SHEET NO. 2	0F 3
ITEM Ground Water Flow	Thru Bedrock	BY JMC	DATE 5-24-90
		CHKD: BY	DATE

Conservative K value for bedrock = 10-7 cm/sec conversion to ft/day:

10-7cm = .0000001 cm x 2835 ft = .0002835 ft day

Volume of flow:

gradient x K x Surface area:
-26 x .0002835 ft x 338, 250ft = 24.93 ft 3
day

hssumptions:

K value = 10 -9 cm/sec = .000000001

conversion to  $ft^3/day$ :
.000000001 cm x 2835 ft x.26 x338,250 ft² = .25 ft³
day

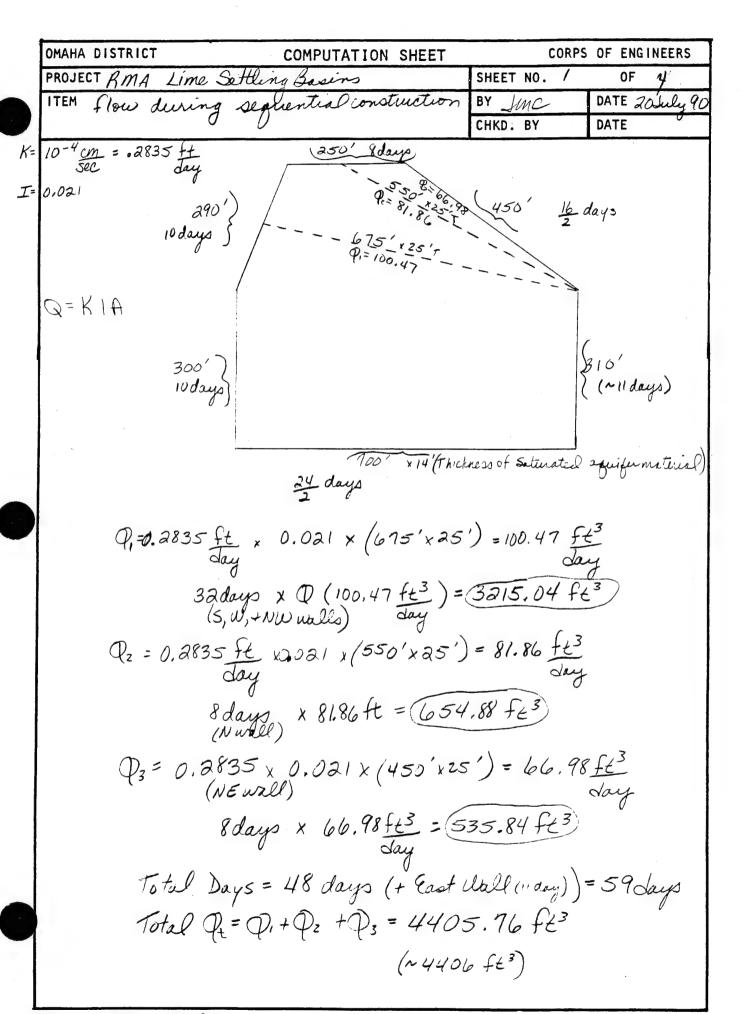
Kvalue = 10-8 cm/sec = .00000001

conversion to ft3/day:

.00000001 cm x 2835 ft x . 26 x 338, 250 ft = 2.49 ft 3

OMAHA DISTRICT	COMPUTATION SHEET	CORPS	OF ENGINEERS
PROJECT RMA-Lime Set	Hina Basins	SHEET NO. 3	0F <u>3</u>
ITEM Total Ground Water		BY JMC	DATE 5-24-90
	AND bedrock	CHKD. BY	DATE

ESTIMATES OF GROUNDWATER FLOW RANGE FROM~17 to 40 ft3 day



MRO Form 1550, 1 DEC 83

OMAHA DISTRICT	COMPUTATION SHEET	CORPS	OF ENGINEERS
PROJECT	•	SHEET NO.	0F 4
ITEM		BY JMC	DATE 20 July 90
		CHKD. BY	DATE //

East Wall-no significant Q

South Wall - 700' = 30' 23.3 days = 211.67

,2835 x.021 x (700' x14') = 58.34 ft<sup>3</sup>

ft ft ft<sup>2</sup> day

A.67 days x 58.34 ft<sup>3</sup> = 680.83 ft<sup>3</sup>/
day

(12 days x 58.34 = 100.88 ft<sup>3</sup>/day)

West Noll - 300' + 30' = 10 days .2835 x.021 x (300 x25) = 44.65 ft 3/day 10days x 44.65 ft3/days = 446.51

NorthWestWall  $a90' \div 30 = 9.67 \text{ days}$   $.2835 \times .021 \times (290' \times 25') = 43.16 \text{ ft}^3/\text{day}$   $9.67 \text{ days} \times 43.16 = 417.39$  $10 \text{ days} \times 43.16 = 431.60$ 

Novable 250' = 30' = 8,33 = 2 = 4.17 Lays .2835 x.021 x(250' x 25') = 37.21 4.17 Lays x 37.21 ft Jay = 155.16 4 Lays x 37.21 = 148.84

North East Mall  $450' \div 30 = 15 \div 2 = 7.5 \text{ days}$   $.2835 \times .021 \times (450' \times 25') = 66.98$   $7.5 \times 66.98 = 502.33$  $8 \times 66.98 = 535.84$ 

OMAHA DISTRICT	COMPUTATION SHEET	CORPS	OF ENGINEERS
PROJECT		SHEET NO. 3	OF Ц
ITEM		BY JMC	DATE 20 July 90
		CHKD: BY	DATE U

midpoint from NW Wall 675 ft :30 ft/day = 22.5 days
$$Q = .2835 \times .021 \times (675 \times 25) = 100.47$$
(5W4NW vary)
$$22.5 days \times 100.47 = 2260.47$$

$$23 \times 100.47 = 2310.81$$

medpoint from N wall 550 ft 
$$\div 30 ft = 18.3 \div 2 = 9.17$$
day
$$.2835 \times .021 \times (550 \times 25) = 81.86$$

$$9.17 \times 81.86 = 750.66$$

$$9 \times 81.86 = 136.74$$

OMAHA DISTRICT	COMPUTATION SHEET	CORF	PS OF ENGINEERS
PROJECT			4 OF 4
ITEM		CHKD: BY	DATE 20 July 97
Sequential C	Ponstruction	CRND. C.	DATE
Sequential Co		//	
	tWall	[/	
Sou	thwall	12	
_	twalf	10	
Nort	therest wall	10	1
Nort	thwalf	4	
Nort	cheast Wall	8	
mil,	point from NW Wall	23	
mede	point from N wall	9	
	U	81 day	$\wp$
0		V	
Ear	st Wall	~	
Sou	ithWall	100,08	
We	est Wall	446.51	
	rthwest Wall	431.60	
Non	ith Wall	148.84	
$N\sigma$	rtheast Wall	535.84	
MC	dpoint from Nuwall	23/0.81	
	apoint from N Wall	736.74	
		= 5310.4	3 ft3
		Total Ds	luring consit

TABLE 1
SOIL-BENTONITE SLURRY TRENCH QUALITY CONTROL TESTING

Subject		Test	
Bentonite Powder	Standard API STD-13A	Specific Test  a. YP/PV Ratio  b. Plastic Viscosity  c. Filtrate  d. Record:  dl. Wet Screen  Analysis  d2. Moisture Content	Frequency 1 per truck shipment (100 bags)
Chemical Analysis of Water	API RP 13B-1	<ul><li>a. pH</li><li>b. Hardness</li><li>c. Total Dissolved</li><li>Solids</li></ul>	Initially and monthly thereafter
	ASTM D152	d. Oil, Organics etc. Chloride	1 per water supply source or if changes occur
Initial Soil Bentonite Slurry Properties	API RP 13B-1	<ul><li>a. Viscosity</li><li>b. Density</li><li>c. pH</li></ul>	3 per shift (see Note 1)
In-Trench Soil Bentonite Slurry Properties	API RP 13B-1	<ul><li>a. Viscosity</li><li>b. Density</li><li>c. Sand Content</li></ul>	3 per shift (see Note 1)
Backfill Material	ASTM D 422 ASTM D 4318	Grain Size Atterberg limits	1 per 500 cubic yds
Soil-Bentonite Backfill Material	ASTM C 143 API RP 13B-1	Slump Cone Density	3 per shift (see Note 1)
	ASTM D 422	Grain Size	1 per 2000 cubic yds
	ASTM D 2216 EM 1110-2-1906	Moisture Permeability	1 per 100 ft. length or per new batch (see Note 2)
Compacted Clay	ASTM D 422 ASTM D 2922 ASTM D 3017	Grain Size Density (Nuclear) Moisture (Nuclear)	<pre>1 per 2000   cubic yds 5 per lift 5 per lift</pre>

#### Notes:

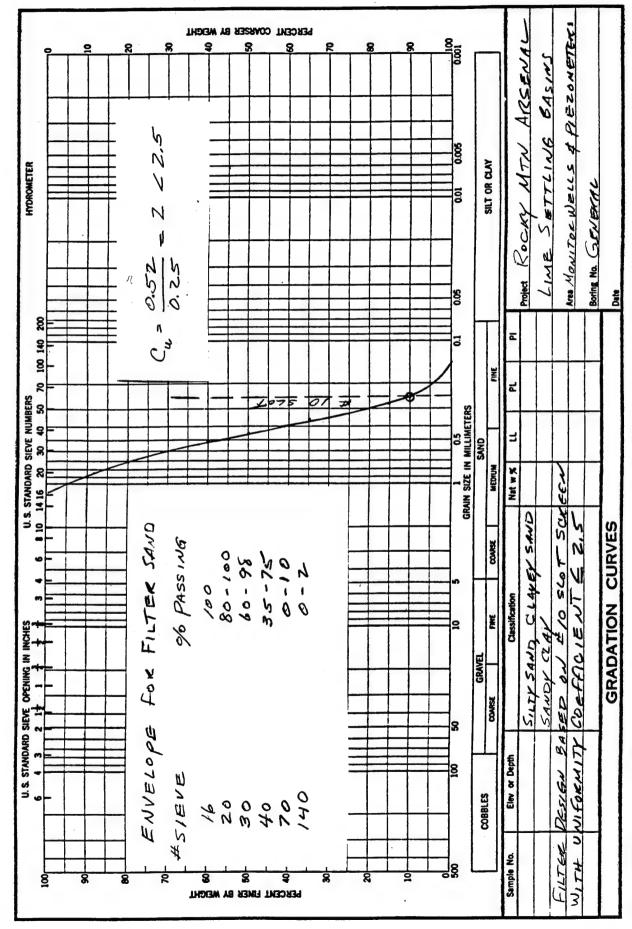
- 1) If more than one (1) batching plant is being used, these frequencies shall apply to each batching plant separately.
- 2) Permeability test may be performed using fixed wall permeameter except that for every five such tests, there shall be performed one test using flexible wall permeameter.
- 3) Requirements of permeability on completed soil-bentonite cutoff wall are specified in Subparagraph: Slurry Trench.

TABLE 2
SOIL-BENTONITE SLURRY TRENCH QUALITY ASSURANCE TESTING

Subject .		Test	
	Standard	Specific Test	Frequency
Initial Soil	API RP 13B-1	a. Viscosity	1 per 3
Bentonite Slurry		b. Density	shifts
Properties		c. pH	(Note 1)
In-Trench Soil	API RP 13B-1	a. Viscosity	1 per 3
Bentonite Slurry		b. Density	shifts
Properties		c. Sand Content	(Note 1)
Backfill Material	ASTM D 422	Grain Size	1 per 5000
	ASTM D 4318	Atterberg limits	cubic yds
Soil-Bentonite	ASTM C 143	Slump Cone	1 per 3
Backfill Material	API RP 13B-1	Density	shifts (Note 1)
	ASTM D 422	Grain Size	1 per 10000 cubic yds
	ASTM D 2216	Moisture	1 per 500
	EM 1110-2-1906	Permeability	ft. length or per new batch (Note 2)

#### Notes:

- 1) If more than one (1) batching plant is being used, these frequencies shall apply to each batching plant separately.
- 2) Permeability test may be performed using fixed wall permeameter except that for every five such tests, there shall be performed one test using flexible wall permeameter.
- 3) Requirements of permeability on completed soil-bentonite cutoff wall are specified in Subparagraph: Slurry Trench.



ENG , MAY 83 2087

VEGETATIVE COVER FOR LIME SETTLING BASINS ROCKY MOUNTAIN ARSENAL, COLORADO OCTOBER 12, 1990

#### POOR GRASS

## LAYER 1

### VERTICAL PERCOLATION LAYER

THICKNESS	=	6.00 INCHES
ROSITY	=	0.4370 VOL/VOL
ELD CAPACITY	=	0.1053 VOL/VOL
ILTING POINT	=	0.0466 VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.0815 VOL/VOL
SATURATED HYDRAILLIC CONDUCTIVITY	=	0.003060000017 CM/

# LAYER 2

#### VERTICAL PERCOLATION LAYER

THICKNESS	=	12.00 INCHES
POROSITY	=	0.3394 VOL/VOL
FIELD CAPACITY	=	0.0906 VOL/VOL
WILTING POINT	=	0.0466 VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.0771 VOL/VOL
SATURATED HYDRAULIC CONDUCTIVITY	=	0.000085000000 CM/SEC

#### GENERAL SIMULATION DATA

SCS RUNOFF CURVE NUMBER = 73.68
OTAL AREA OF COVER = 385000. SQ FT
EVAPORATIVE ZONE DEPTH = 14.00 INCHES
UPPER LIMIT VEG. STORAGE = 5.3372 INCHES
INITIAL VEG. STORAGE = 0.9741 INCHES

SOIL WATER CONTENT INITIALIZED BY PROGRAM.

# CLIMATOLOGICAL DATA

DEFAULT RAINFALL WITH SYNTHETIC DAILY TEMPERATURES AND SOLAR RADIATION FOR DENVER COLORADO

MAXIMUM LEAF AREA INDEX = 1.00 START OF GROWING SEASON (JULIAN DATE) = 128 END OF GROWING SEASON (JULIAN DATE) = 284

#### NORMAL MEAN MONTHLY TEMPERATURES, DEGREES FAHRENHEIT

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
29.50	33.60	38.00	47.40	57.20	67.00
73.30	71.40	62.60	51.90	38.70	32.60

\*

	AVERAGE	MONTHLY	VALUES	IN	INCHES	FOR	YEAF	RS	74	THROUGH	76	
	*>		JAN/JU	JL I	FEB/AUG	MAR/	'SEP	APR/	OCT	MAY/NOV	JUN/DEC	
PRI	ECIPITATI	ON										

IUIALS	 	 	1.40	
STD. DEVIATION			1.37 0.78	

# RUNOFF

TOTATO

TOTALS					0.000	
STD. DEVIATIONS	0.000	0.000	0.000	0.000	0.000	0.000

0.000 0.000 0.000 0.000

0.000

0.000

## EVAPOTRANSPIRATION

TOTALS	 	1.116 0.850		 
STD. DEVIATIONS	 	0.231 0.584	• • • • •	 

## PERCOLATION FROM LAYER 2

TOTALS			$0.0008 \\ 0.0010$	
STD. DEVIATIONS			0.0005 0.0003	

***********	***********	******	******
AVERAGE ANNUAL TOTALS & (STI	D. DEVIATIONS) FOR Y	EARS 74 THRO	OUGH 76
	(INCHES)	(CU. FT.)	PERCENT
ECIPITATION	14.32 (1.079)	459327.	100.00
NOFF	0.000 ( 0.000)	0.	0.00
EVAPOTRANSPIRATION	14.353 ( 0.604)	460508.	100.26
PERCOLATION FROM LAYER 2	0.0115 ( 0.0018)	369.	0.08
CHANGE IN WATER STORAGE	-0.048 ( 0.550)	-1551.	-0.34
*********	*******	*****	*****

\*

	PEAK DAILY VALUES FOR YEARS	74 THROUGH	76
-		(INCHES)	(CU. FT.)
	PRECIPITATION	1.79	57429.2
	RUNOFF	0.000	0.0
	PERCOLATION FROM LAYER 2	YER 2 0.0001	
	SNOW WATER	0.47	15079.2
	MAXIMUM VEG. SOIL WATER (VOL/VOL)	0.1686	
	MINIMUM VEG. SOIL WATER (VOL/VOL)	0.0463	
****	************	*****	*****

\*

	FINAL WATER	STORAGE AT	END OF YEAR	76
	LAYER	(INCHES)	(VOL/VOL)	)
	1	0.42	0.0695	•
	2	0.85	0.0710	
	SNOW WATER	0.00		
*********	******	******	******	********

\*

	CONVERSATION	ON RECORD	T	IME 10:00 a	m DATE	FEB	1990	
TYPE	□ VISIT	☐ CONFE	RENCE	⊠ TELEPI	<b>⊠</b> INCOM	ING	ROUTING AME/SYMBOL	INT
	f Visit/Conference:	- Land	TION (Office day	A humau 17	OUTGO			
NAME OF PE	ERSON(S) CONTACTED OR IN C	etc.)	ZATION (Office, dept					
	ARK ZAPPI	CEW	ES-EE-S	(6	101) 634-	2854		
SUBJECT	LURRY WALL	COMPATI	BILITY	ESTIN	o,	_		
	ROCKY MO	DUNTAIN F	PRSENAL					
SUMMARY	OUR BASIC	PLAN FO	OR SLUR	RY U	UALL	Comi	PATIBIL	ITY
TEST	ING IS OK	BUT NE	EDS SC	mE	FINE	TUL	IE ING.	
	RECOMMENDE	D USING	MOSTLY	Y FLE	XIBLE	E W	ALL	
	EAMETERS BU							WA
SINCE	FLEXIBLE W	PALLS DON'	T SHOW	SAMI	ole s	HRIN	KAGE.	
HE A	ALSO SUGGES	TED RUNK	HUG EAC	H Spn	nplb	IN TH	RIPLICAT	FE
	- SAID RUN F							
•	R THROUGH							<u> </u>
	VOLUMES DE							
CALCII	UM IN THE S	OILS (LIME	SETTLING	Basins	s) cov	LD E	XCHAN	G-E
WITH	SODIUM IN A	BENTONITE	TO INCR	EASE P	ERME	ABILIT	TY AND	0
SUGGI	TRACKI ESTED RUNDT	NG SODIUM	AND CAL	-cium 1	INTO F	AND C	OUT OF	TI
	Em. HE SUG							
TESTS	S IF MRD LI	AB COULD	HOT DO	7 TES	TING.	MARK TH PE	SAID -	TRY
TO DE	TERMINE A BRE	PK THROUGH	TIME 15 /	9 GOOD	IDEA	BUT	NOT	
ACTION F	REQUIRED			0=1110	A BOL	IF IN	FORMA	71
UF	REQUIRED SCOPE O	of Services	PEORPOR	n I I N G	7,000		_	
Lo	OK FURTHER	INTO USIN	3 WES	LAB F	OR TE		テ、 	
NAME OF	PERSON DOCUMENTING CONV	ERSATION SIG	NATURE			DATE		ion.
JA	NE M. BOLTO	.	Jane M.	Bolte	on	6 F	E.B. 144	EP .
	TESTING	., , ,						
SIGNATURE	Ξ	TIT	LE		1	DATE		
	1 200 0 0	ton	CIVIL ENG	INEER		20 f	EB. 19	90
	Jone M. Bol		J(010 <u>1</u> 700	TO COLA		OPTI	ONAL FORM 27	71 (12

CONVERSATION RECORD

DEPARTMENT OF DEFENSE

CONVERGATION DECOR	TIME	DATE
CONVERSATION RECOR	12:45	
TYPE USIT CO	NFERENCE TELE	NAME/SYMBOL IA
Location of Visit/Conference:		図 INCOMING
NAME OF PERSON(S) CONTACTED OR IN CONTACT ORG	ANIZATION (Office, dept., bureau,	
with you etc.)	1	(303)
SUBJECT	ORADO STATE UNIV.	1441-0387
ROCKY MTN. ARSENAL - M	1-1 BASINS	
SHEET PILE DESIGN		
SUMMARY		
DR. CHARLIE WAS INFORT	MED THAT WE	WERE DESIGNING !
SHEET PILE WALL AT RMA	TO PREVENT M	TIGRATION OF GROUNDW
INTO THE AREA TO BE VITRIFI	ED. AND WE NE	SOED INFORMATION
	•	
ABOUT WHAT TYPE OF SHEET	PILE TO SPECIFY	BASED ON BLOW COUN
DURING EXPLORATORY DRILLING.	HE SAID THERE	IS INFO, IN THE NAU
DESIGN MANUAL 7.2 BARTH	& FARTH RETAININ	IG STRUCTURES. HE ALS
HAS SOME INFO, THAT HE WILL	L tax me. TE	SAID THE BLOW COUN
ISING 3" DIAMETER SPLIT SP	CONST. WOULD BE	HIGHER THAN WITH
SPT 2' SPLIT SPOONS. I ALS	o Expressen c	CALCERUS AROUT
VIBRATIONS CAUSING PROBLEM.	S WITH ADJACEN	T STRUCTURES LEFT I
PLACE (> 20 FT. AWAY). HE	SAID AN ASCE !	ARTICLE ABOUT CONSTRI
VIBRATIONS PASSED OUT IN HIS	S SOIL DYNAMIC	S CLASS WOULD HAV
NFO. BUT THAT PROBABLY IF	PEAK VIBRATION	S WERE BELOW   OR
INCHES SEC. THINGS WO	PULD BE OK	HE ALSO RECOMME
ISING A VIBRATORY HAMME	R INSTEAD OF A	DRIVING HAMMER AN
CTION REQUIRED		
LOCATE REFERENCES AND U	SE IN DESIGN.	
AME OF PERSON DOCUMENTING CONVERSATION   SI	IGNATURE	DATE
		915190
	Jane Bolton	115190
CTION TAKEN		
REFERENCES LOCATED, VIBRE		
PUT IN PLANS & SPECS. SIZE	THE	DATE
1		
Jane Bolton	CIVIL ENGINEER	9/25/90

CONVERSATION RECO	ואט			
YPE				ROUTING
visit 🗆	CONFERENCE	TELEPHONI	INCOMING	NAME/SYMBOL I
ocation of Visit/Conference:		ä	OUTGOING	
AME OF PERSON(S) CONTACTED OR IN CONTACT	ORGANIZATION (Office, o	lept., bureau, TELE	HONE NO:	
ITH YOU	etc.)			
UBJECT				Ī
OBJEO:				-
UMMARY				
CONT.				
MAYBE PUTTING A FEN	SETTLEM	ENT MA	RKERS	NEAR SON
STRUCTURES AND MONIT	ORING TH	EM ONC	E A D	MY MI
THE BEGINNING OF DRIVING	NG TO SEE	IF THERE	ARE	ANY
froelems.				
·				
			GINEERING	
( DR. CHARLIE IS AN A	SSOCIATE F			CSU
		ROFESSOR	ART	
SAECIALIZING IN SOIL	DYNAMIC	ROFESSOR S AND	A AT (	
	DYNAMIC	ROFESSOR S AND	A AT (	
SAECIALIZING IN SOIL	DYNAMIC	ROFESSOR S AND	A AT (	
SAECIALIZING IN SOIL	DYNAMIC	ROFESSOR S AND	A AT (	
SAECIALIZING IN SOIL	DYNAMIC	ROFESSOR S AND	A AT (	
SAECIALIZING IN SOIL	DYNAMIC	ROFESSOR S AND	A AT (	
SAECIALIZING IN SOIL	DYNAMIC	ROFESSOR S AND	A AT (	
SPECIALIZING IN SOIL HE WAS MY GRADUATI	DYNAMIC	ROFESSOR S AND	A AT (	
SAECIALIZING IN SOIL	DYNAMIC	ROFESSOR S AND	A AT (	
SPECIALIZING IN SOIL HE WAS MY GRADUATI	DYNAMIC	ROFESSOR S AND	A AT (	
SPECIALIZING IN SOIL HE WAS MY GRADUATI	DYNAMIC PROGRA	ROFESSOR S AND	A AT (	
SPECIALIZING IN SOIL HE WAS MY GRADUATI	DYNAMIC	ROFESSOR S AND	AAT ( FOUNDA  OR )	
SPECIALIZING IN SOIL HE WAS MY GRADUATI  ACTION REQUIRED  NAME OF PERSON DOCUMENTING CONVERSATION	DYNAMIC PROGRA	ROFESSOR S AND	AAT ( FOUNDA  OR )	
SPECIALIZING IN SOIL HE WAS MY GRADUATI	DYNAMIC PROGRA	ROFESSOR S AND	AAT ( FOUNDA  OR )	
SPECIALIZING IN SOIL HE WAS MY GRADUATI  ACTION REQUIRED  NAME OF PERSON DOCUMENTING CONVERSATION	DYNAMIC PROGRA	ROFESSOR S AND	AAT ( FOUNDA  OR )	
SPECIALIZING IN SOIL HE WAS MY GRADUATI  ACTION REQUIRED  NAME OF PERSON DOCUMENTING CONVERSATION	DYNAMIC PROGRA	ROFESSOR S AND	AAT ( FOUNDA  OR )	

\$U.S. GPO: 1987—181-247/80053

50271-101

CONVERSATION RECORD

OPTIONAL FORM 271 (12-76) DEPARTMENT OF DEFENSE

CONVERSATION REC	CORD	TIME 8:30 Pm	DATE   10/2/	90
TYPE	CONFERENCE	₩ TELEPHON		ROUTING
□ VISIT [	CONFERENCE		INCOMING	NAME/SYMBOL INT
Location of Visit/Conference:			OUTGOING	
NAME OF PERSON(S) CONTACTED OR IN CONTACT WITH YOU	ORGANIZATION (Office, etc.)	dept., bureau, TELE	PHONE NO:	
MIKE SNEIDER		962	- 4772	
SLURRY TRENCH '	SET -UP"	TIME	·	
			<u></u>	
SUMMARY	- 0			
MR. SNEIDER WAS	INFORMED	OF MY	QUE	STIONS
AND CONCERNS ABO	OUT THE N	UMBER	DF DAY	S FOLLOWIN
SLURRY WALL BACKE	ILL INSTALL	ATION	BEFORE	HEAUY
EQUIPMENT CAN CRO	SS THE WI	ALL WI	THOUT	DAMAGE.
HE SAID ON KANE A	NO LOMBA	RD THE	SOIL-BI	ENTONITE
BACKFILL DID A LOT	OF HAR	DENING	NITHIN	2-3 DAY
AFTER INSTALL ATION	. HE RECO	OMMEND	ED PLA	CING THE
CLAY COVERA 2-3 DA				
ASKED ABOUT HEAVY				
HE RECOMMENDED A				
CLAY AT THE CROS				
	· · · · · · · · · · · · · · · · · · ·			
ACTION REQUIRED		الا عدد الا	C - 2	
INCORPORATE INF	EO. INTO P	LANS ?.	SPECS	
NAME OF PERSON DOCUMENTING CONVERSATION	SIGNATURE	0 1	DATE	- 1-
JANE BOLTON	Jane B.	olton	101	2/90
ACTION TAKEN				
INFO. INCORPORAT	ED			
SIGNATURE	TITLE	·	DATE	
Jane Bolton	CIVIL E	UGINEER	101	3/90
50271-101 \$U.S. QPO: 1987181-247/80052	CONVERSATION REC	ORD		IONAL FORM 271 (12-76) ARTMENT OF DEFENSE

Woodward-Clyde Consultants PROJECT NAME \_ RMA COE BORING LOCATION 36 DRILLER K, Cross orne Western Term UNDIST. DHILL DI Hollow Auger 24 HRS. NA FROM TYPE OF PERFORATION T. Terr 10 FHOM . SIZE AND TYPE OF 10 35 FROM TYPE OF SEAL GRAPHIC LOC DESCRIPTION (Drill Rate, Fuld loss, Oder, etc Fill, sand, grayish white chunks and crystals, moist, appears to be lime, brown, light gray, dark brown 12 12 Sand, very moist to wet, loose, light brownish gray, 2 10YR5/2 2 silty O PPM 3 10

A22-1

89 MC114A

PROJECT NO.\_

SHEET\_/

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,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,	ward-Clyde Consultants The PROJECT NAME	GHAPH	C LOG	-	: [	SAM	PLES	PIDP	PM
E	• DESCRIPTION	Lithology	Plezemeter Installation	Weie r Conten	Deta	7 pe Me.	1 = 1 E	REMARI (Dritt Rale, Fluid	Ses, Oder, etc.
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′‡		/			‡				1
5+		\";			Ŧ	$\exists$	5	24.9	
, ‡				·	. ‡		7		1
, +	Sand very silty, grayish	1			∧‡	_	8		.
, <del>I</del>	Sand, very silty, grayish brown, wet, medium dense, iron oxide staining (SM)	1.		1	4				
· ‡	iron oxide staining (SM)	\\ \	2	\$	#				1
}‡	10YR6/2	(: N			Ŧ				
‡.			4/		#		Ne. (1)		
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+	/		~; .		ŧ		4		
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Ŧ	Clay, trace sand and silt,			_	‡	11	"		.
+	wet, brown, stiff to			>	Ŧ	. 11			/
‡;	wet, brown, stiff to very stiff (cL)	/			#	-			
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IECT	NO. 89 MC 114 A				•			SHEET _	50F2

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Voodward-Clyde	Consultants (		PROJECT	NAME

ا م		GHAPI	וכ גספ	1.5	<u> </u>	5/	MPLES			
DEPTH (TEET)	DESCRIPTION	Lithology	Plezometer Installetion	Wo!e	P'azon. Dele	Type No.	Print.	( C	III Rale,	MARKS Fluid lace, Odor, e
32-	Claystone, silty, firm to haid	/			3					
33 +	Claystone, silty, firm to hard fractured, ironoxide staining (CH) 1048513, 10484/2			•		0				
#	staining (CH)				#	R	1.			
34‡	1048513, 104R4/Z				+	뒤	1.	.   '		
35 =	DENVER FORMATION .			1	注		'			
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)JECT N	10. 89 MC 114A								SHEET	<u>3</u> or <u>3</u>

A22-3

Woodward-Clyde Consultants PROJECT NAME \_ McKay Western DRILL DIT FIRST 10 LOGGED BY TYPE OF PERFORATION T. Terry 10 FROM SIZE AND TYPE OF PACK 1032,5FT FROM TYPE OF SEAL Grout DEPTH GEET) DESCRIPTION Fill, Sand, lime, moist, white, brown, trace. gravel, 104R8/1,104R4/3 13 8 7, 8 3 3 Sand, little silt, very moist, wet, loose, dark grayish brown, (SP) 2. 10YR4/2 2 1/ 3 Sand, silty, wet, medium dense to dense, yellowish brown, (SM), 10YR5/4

PROJECT NO. 89 M € 114 A

परस्थात्रभाग

SHEET\_/\_OF . 2

Wood	ward-Clyde Consultants (III) PROJECT NAM		c LOG		E T	SA	MPLES	PID DDM
33		Lithology	Plezometer Installetton	ote P	600	\$	# # # F F E	REMARKS
WE ET	• DEZCHILLION		installetion	> ວ	2	Ē	S S S S	COMMINICAL PRINT MINICAL PRINT
14-		36			Ιŧ	٠		
ľŦ			1		H			
15+					‡	$\overline{\cdot}$	7	37.2
Į		1			ΙĮ		8	3112
16 ‡					Ī	•	10	
‡		1			‡			
17+					1			
I	Clay (Weathered Claystone)		1	. 1	Į			
18‡	very stiff, pale brown,		$f_{j}$		‡	٠.		•
Ī	yellowish brown, fractured,				lĪ			
19 =	blocky, (CL)				‡	•		
'   ‡		1			‡			
20 I	10 YR 6/3, 10 YR 5/4				<del> </del>	ᅱ	8	0.0
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26	The state of the s				‡	-	.   13	
77		1			1	.		
1/I	Claystone, siltstone, hard to very hard, yellowish brown, iron oxide staining, (CH), 104R5/4				ĮĮ			
1	had toward hand vellowish				‡	.		
28+	nara tovery mary forming				‡			
70 t	prown, iron exide stanning)				‡	.		
29+	(CH), IUTKOIT				I			
30					‡	$\dashv$	12	
Ī		P A			‡		23	11.9
21.					‡	.	1	•
31+		-			}	ᅴ	30	4.7
32					‡	8		1. /
	Ga MC IIII A							SHEET 2 OF Z
PROJEC	T NO. 89MC114A							

COE D.O. 1 HOLE NO. LSB-3 Woodward-Clyde Consultants PROJECT NAME. BASINS BURING LOCATION LYME STITUMY DRILLERM, WALKER LAXNE -WESTERN SAUPLEHY 400 SAITSPON HSA. DHILLING EQUIPMENT ONE 750 W/ 6-5/5 DRILL DIT UHILLING METINOU HS/low ston arrepus SIZE AND TYPE OF CASING WATER ELEV. LOGGED UY TYPE OF PERFORATION SIZE AND TYPE OF PACK 5 morrissette 10 37.5FT FROM O TYPE OF SEAL GPOUT GRAPHIC LOG REMARKS DESCRIPTION (Drill Rate, Fuld loss, Odor, etc.) (5m) growally silty SANOs very fine grands Topsoil 1042 4/3 brown to dark brown SM) Silty SANO, fine-grained, poorly graded, medium derse, dry, 10/K4/3 brown to dark brown PIO=ND 8 12 PED= 2.0 ppm - becomes slightly clayey 1 becomes 10 yelf light yellowish brus PEO=ND poorly graded, medium dense, very moist, loyko/4 light pllusish Allwinn 6 5 PIO=3.01Pm 11 12 water outers ATD (SM) Silfy SAND, fine-grained, poorly graded, madium bense, wet, - loyns/4 yellowish-brown Allwinn 89mc114A OF 3

কুলে ক্রিন্তাল করে। ক্রিন্তুল ক্রিন্তুল ক্রিন্তুল ক্রিন্তুল ক্রিন্তুল ক্রিন্তুল ক্রিন্তুল ক্রিন্তুল ক্রিন্তুল ক্রিন্তুল ক্রিন্তুল

PROJECT NO.

A22-6

SHEET.

MA			
	PROJECT	NAME	-

		GHAPH	C LOG		30,5	-34		LES	REMARKS
0EPTH (FEET)	DESCRIPTION	Lithelogy	Plezameler Installetion	Wo!e	Piezy	e v.	Press.	A SECTION OF THE PERSON OF THE	
14	- SAME" (SM) silty SAND, fine quint							٠	Allusium
5	- wet, 10 yes/4 yellow: 34 - brown							7	PID=29 ppm
<u>:</u> -ط						- - - - -	14	13	P. D. D. W.
7						. 1			
<i>X</i> -			1/		, ,	1 ./			•
9								> .	<b>\</b>
' ‡							·		
0-	(CL) sandy silty ccay, low to medium	34 JE	> .		1	<u>.</u>	17	69	Allwinn ,
1/-] 	very moist, 10 VRS/3 brown to	- (					+		reworked shall belouk
W]	104/27/3 very pale brown				1				
3-		4	7						de de la companya de
¥‡					=	-			1.
5	(CH) silty day Stave, highly plastice firm very moist, 1042-12				-		1	7	Denver Finishly weathered
6-	string carbonacius					SS	15	17	p=0=17ppm
2‡ 2‡					-	-			
8	becoming unwestlered				-	-			Stiffen
5						_	+	$\dashv$	Core run#1
δ	Claystone				-	0			<b>4 6 6 7 8</b>
=	; ;				. ]	R	2		· .
7-						٦			
12-	XGuciiUA						_		SHEET OF Z

MANE	LOE.	D,0		1
 WINE			-	

		I GHAPH	IC LOG		2	SAL	PLES	
OCPTH (FEET)	DESCRIPTION	Lithology	Plazometer inclellation	Content	Pittonite Bride	ype Mg	1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1	REMARKS (Dritt Role, Field less, Oder, etc.)
32	(CH) sitty clay state, highly dastic, medium hard giveng moist, 10/22/2 very duk brown, ivon oxide stains, carboniceous				#	C		Demar From
33	10/2 2/2 very duke brown ,					É	-	
34	- claystone	•	·		=			Bottom of bowing at 33.5 food
35				. 4	+		·	
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DON IFCT	NO 84140114A							SHEET 3 OF 3

Woodward-Clyde Consultants 🍪 PROJ	JECT N	AME		DE				HOLE NO
BORING LOCATION LIME SETTING BASING	S .			ELEVATE	H AM	DAT		
DRILLING AGENCY CAVNE - WESTERN	ILLEH M.	WALLET	<	DATE ST	ISHED	-	7-9-9	FAMPLENDY O S./-/-
DRILLING EQUIPMENT QUE 750 W/6-5/8 "00 A	ISA			COMPLET			<u> </u>	SAMPLERTIGO Solit Spain
DHILLING METHOD Hollow Stem angers	ILL BIT			NO. C	s i	DIST		COMPL NO 124 HRS.
SIZE AND TYPE OF CASING			FL	WATE ELEV	•		7.0	CHECKED BY
TYPE OF PERFORATION FAC		10	FT.			0.35	(275)	
SIZE AND TYPE OF PACK	OM 0			J. 1	nor	دہے	SETTE	
TYPE OF SEAL . GROWT FAC	0	10 29.		6	1	SA	UPLES	
DESCRIPTION DESCRIPTION		Lithology	Pleros Instalk	maler n	Pletoner Dete	Type Wa	Penetra Peret (Sout 6 in)	REMARKS (Drill Role, Field loss, Odor, etc.)
O (SC) clayer sity SANO, fine - grained gradely guery Stiff, mists loyas/	אומסקב		ي .	1	,,,,			Allwium
(Sm) si Hy SAND, fire-grained, pour graded, subsingular to substanded dense, moist, 10 yes/typllow	-ly- ,e,							
2 - lense, moist, 10 yr 5/4 upllow	754 -						14	
3 = brown	<		7			12	15	bid=nd
41				No.				
5 =	-		,			22	4	ρΙΟ=μD
6 <del>1</del>			)		1	-	4	
7 = becomes loya 6/3. and.	wet.	, , - , -			-			without entous ATD
8 = (( ) =					1	- Ss	176	PIO=ND
7 =			-		#			
<i>1</i> •					1	SS	34,	PID=40-8ppm
" <del> </del>					1		4	
12						-		
<i>B</i> ‡					-	-		
14 <sup>±</sup>					土	-		
PROJECT NO. 89mc/144								SHEET OF

A22-9

PROJECT NO.

Noodward-Clyde Consultant	. <b>T</b>	PROJECT	NAME
MOODIWITIO-CIYOO COLLEGE	-		

		GHAPH	IC LOG	- 2	Ē.	gs	15	4	REHARKS
	. • DESCRIPTION .	Lithology	Plezomeler Jactellotlan	Confe	Pietos Per	H edf:	Press.	Tage of	(Dritt Rate, Field Sess, Oder, e
	11 . (A. 1) (m) . Line constitule	1.7.1		<del></del>	-	1		•	Allwium
±2	AME: silty SALO (sm) , fine gravely, porly graded, subangula to			•			П		1
	porty for leve wets				4	-	Н	_	• •
+ .	porly graded subangethe to subsounded g dense, wet, 10/26/3					• •	П	9	PIO=ND
<b>!</b>	104-613				. :	ZŽ	旭	11	•
1/0	L) sandy sitty cray, low plastic,				7	-	П	13	Allwium reworked shale
# 6	mains tiff time area sales good			$\wedge$	. ‡		H		reminer s.
, ‡	10/25/3 brown with 10/28/2 white			· ,		_	П		
+	nothing			3	1	•	П		
<u></u>	Madif it and		_/	1	1		Н		Denvar For
F/c	4) sandy sitty CLAY, highly plastic ,		1 14		+	-			wenthered
70.	medium hard, very moist, loyab/4		. /		· . +	1			
‡ .	1.1 + nellowish -brown		V 1	J	1		1	Sage 1	
#	1192.				7	. "	4	. 1	•
± .	Weathered Claystone				‡			.	
Ŧ					土		$\perp$		
<del>T</del>			ł		7		1	0	•
#	/ 4		) .	- 1	- 7	ss	4	15	PIO=ND
# .				- 1	-	3/	1	24	
Ŧ					Į	$\dashv$	4	01	
#	· / · · · · · · · · · · · · · · · · · ·		The same of			_,			
7-	1		$\langle \cdot \rangle$		$\pm$	- 1	1	- 1	, ,
Ŧ				- 1	Ŧ		1	- 1	. ,
Ŧ::.			7.	- 1		•	1	. 1	Denver Fin
+101	1) sitty copy situes, highly plastics		·	- [	Ŧ		1		unwerthered
£6.	hard, very moist, 10/20/4/ight		•	- 1	+	$\dashv$	4		•
<del>T</del>	wellowish - Some to loya 3/1 dont		1	- 1	+		1	3	1.0
‡	dielith awares		I		Ŧ	35/	ď	20	OID=ND.
#	gray, slightly carbonaceous	,			-1-		٦	25	• •
+				- [	‡_	_	1		Cole pos #1
+		· .		- [	F				Cope post 111
Ŧ. ·					+	C		-	•
Ŧ					t	9			
7			1		Ŧ	2			•
1			.	-	7	( )	3		
‡					#	-	7	- 1	
‡	777 NA. 1		·		+		L	- 1	
<u> </u>			. 1		‡		1		
‡	- A - A - A - A - A - A - A - A - A - A				‡				•
<u>†</u> .			- 1		+	+	十		Button of boring
‡ ·	. \ \ \ / /		- 1	-	‡	1	1	.	Buttom of boring .
‡	•	1	- 1						
‡		1	]		• ‡				
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<b>_</b>		1	- 1		+				
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#	·	1			1	1			4
- -									SHEET 2 OF S
CT AM	89MC114A								SHEET SON SA

Washington Charles Consultants (TA) PROJECT N	AME	DE_	D. 0.	<u></u>	HOLE NO. LID
Moodward-Clyde Consultants PROJECT N		ELEVATIO	N AND DATU		, , e
	WALKER	DATE STA	SHED		-90
DRILLING EQUIPMENT ONE 750 W/ 6-5/8" OD HSA				36.5	SAMPLER 3"00 split spain
DHILLING METHOD Hollow Storm angers DHILL BIT		NO. O	<u> </u>	0	COMPL. AD 24 HAS.
SIZE AND TYPE OF CASING -		WATER ELEV.		4,5	CHECKED BY
TYPE OF PERFORATION FROM	10 FT.	-			
SIZE AND TYPE OF PACK FROM	10 FT.	15. M	prkiss	ene	
TYPE OF SEAL GPOUT FROM O	1036.5ft		SAM	PLES	
DESCRIPTION		ometer delian ≥ 8	Tys Ke	Paraire Beral	REMARKS. (Drill Rate, Fuld loss, Odor, etc.)
(Sm) silty SANO, fine-grained, poorly	1111	1	1		action sout/sill ar fill (?)
gradely subangular to submundely  medium dense, dry, 10 yes/4  upllowish-brown					
+ 0		ė	1	1	
3 - becomes muist		>	- SS K	54	PIO=ND
<i>Υ</i> <u>+</u> <u>+</u>					
5= '		Ì	165 VE	5	PIO=ND
6 = (sm to me) sitty sand to such such		-/	73	4	Allaisum
7 - dense, moist, joyas/2 grangish town			+		Allwinn
8 (Sm) si Hy SAND, fire avaised , airly- grobel, subangular to subvoimable, medium dense, moist, 10 yr 5/4			±  SS   17	6 A	PIO=ND
9 - yollow: Sh -brown			#		witer outers
/o <del>-</del>			1	5.	ATD PID=ND
" <del>+</del> ( ) )			155/1	18	•
12‡			#		
13 =			#		·.
14=			Ŧ		
PROJECT NO. 89MC114A	1-1 1-1				SHEET / OF 3

A22-11

PROJECT NO. \_\_\_

loodwa	rd-Clyde Consultants (III) PROJECT N	ME	DE	٥.	٥.	1	. ·	HOLE NO
(FEE)	DESCRIPTION	Lithology	Plezomeler Installetion	Woter Content	Piazoneter Deta	du edi.	Malan Ma Malan Malan Malan Malan Malan Malan Malan Malan Malan Ma Ma Malan Malan Malan Ma Ma Ma Ma Ma Ma Ma Ma Ma Ma Ma Ma Ma	REMARKS  (Dritt Role, Fluid less, Odor, et
4-SA	me: (sm) sitty smo, fine grained, poorly-graded, subangulow to subsumbed, medium dense,							Allwium
	mist, 10/RS/4 yellowish - brown				. 4	SS	789	
7 <del>[[m=</del>	slightly southy sut, non-plastic, melium dense, very time grained south wet, 104x5/3 brown		·	/		-		alluvium
8 <del>1 /</del>	1) slightly daying silty sawos fine - grained, poorly graded, medium			**.	1 1 1			Allwinn
7 🛨	dense g wet, 10 yr4/4 dark yellowix brown				<b>T</b>			
1-6-	) souly sitty carry low plastic, Stiff fire-graved somo, very moist,	5 - 19	<i>/</i> //		+ 133	22 18	5 7 10	PID=12D Allow: um reworked shale
1	loyas/2 white to loyes/3 very pule brown				###	•		
(CH)	Souly silty ceny, highly plastice, hard, fine-grained sand, blocky		7		+			Donver Fin weathered
i w	loyes/3 brum, carboneceuns reathered Claystone				1	·		
	slightly sandy sitty ccay, highly plasting				15	SIL	24 32	P=0=ND Demon For
Ŧ	irm exide stains				+++			unweithered
	laystone				++++			
‡					+		:	
<del>-</del>					<u>+</u> 		41 65	PID=19ppm
					100	$\prod$		CORT RUN #1

,	V00	dward-Clyde Consultants (1) Problem Name			GHAPHIC LOG			SAMPLES				
	0EP1H (FEET)	DESCRIPTION		Lithology	Plezometer Installetion	Water Conten	Pid 20m	2 2	A TEN	(Drill Rel	REUARKS	
1	32-	- SAME: (CH) slightly sandy	silfy cupy;				‡,			De	mer	Fin
	2~	highly plastic, wery I moisty loyks/3 brown oxide stains	involg				1			l line		•
	3D-	moisty loyks/3 brown	, ,,,,,					2				: •
	34:					~					•	
	35 <b>-</b>						1					
	-رر : ٠		·				Ī					
	36-					1	#					
1	•		·				-	T		Botto	36.5	boring et
ŀ	37-	<del>-</del>					‡					
1	38						1				•	
			<u> </u>				1					
1	S -	<b>.</b>		1			‡					
1	6-		The state of the s				‡					<i>i</i> <i>i</i>
	//-				_		‡					
1	'/ <del>]</del>	· · · · · · · · · · · · · · · · · · ·					#			·		·
1	12-	·	1				‡		` ` .		<i>:</i> .	
1	, ‡			,			‡_					: .
ľ	13-	•					‡			•		
5	4			.			+					
	‡						<u> </u>	$\  \ $			•	
4	15						1					
9	6						+				•	
	‡						1					•
9	7						I					
9	8	-					.‡					
1	=======================================						1			٠.		
7	9	•					‡					
1	36-	•					<u>-</u> F_				2	
<u></u>	L	~ 8Gmc114A	,							SIII	EET 3	.or <u> </u>

•	Woodward-Clyde Consultants PROJECT NAME		DE I	٥,۷	<u>. I</u>		HOLE NO. LSB
	BORING LOCATION LIMESETTERY BASINS				DATU	М	4 . 4 . B
	DHILLING AGENCY LAYNE -WESTER DHILLEN Q. ALG	ritton	DATE ST	ARTED			90 / 6-21-90
	DHILLING EQUIPMENT CIME 55 WIX 6-1/8"OD HSA		COMPLET			17.5	SAMPLER 3.0 OD SS
	UHILLING METHOUTHOLLOW Stem angers   DHILL BIT		NO. O	\$	DISL	10	COMPL 2 2 124 IRS.
	SIZE AND TYPE OF CASING -		WATE	<u> </u>	FIRST	5.5	CHECKED BY
	TYPE OF PERFORATION TO TO	- FT.	LOGGED		••		CHECKED BY
	SIZE AND TYPE OF PACK FRUM TO	FT.	S. W	lora	2(3)	377	
	TYPE OF SEAL - GROWT FHOM 5 104	7.5ET					
	DESCRIPTION Lithole		- 2	Pletamere Doia	# 5	*LES	REMARICS (Drill Rate, Fluid loss, Oder, etc.)
0	05 (0100)	- Imia	otion #8	=	F 5	5 60 0 5 20 0	
	Silty SAND, fine-grained, poorly S = griled, medium dense, moist, 10 yr 4/4 davk yellowish -brown,	7	AA	‡			Aedion sand \$
11	I joyr 4/4 dark yellowish -brown,	<b>]</b> ] <		#			
				Ŧ			
2	±			I			
	[ ] [ ] [ ]			I	Τ,	77	PIO=ND
.3	T AND			‡5	15/14	9	P10-45
4	· 注:	11 7		Ŧ	-11		
7	1:11:1			ŧ			. , 1
<	becomes siltier and move moist		$\sqrt{\lambda}$	+		4	
#	±	•:		<u></u> 5.	s 18	4.5	PIO=ND
6	<b>手</b> へり加		71.1	丰	41		
1	I	:	-	‡			
7	the soft non-classic Soft			+			Alluvium
	Soundy Stot, non-plastic, Soft,  very moist, 10 yr 4/4 dank	7		‡	++		
8	tyellowish - brown	}		+		1, 1	DIS-ND
	becomes wet			‡		1	_ water enters
9	= silty Sand (SM)			1	++	-	
				‡	$\prod$		·
10		1	11	+	++		
				† < <	, , <u>,</u>	5	DIO=ND
11	Ksilty SAND, firegrained, poorly Sm	1		7		12	Allwoinn
	graled, medium dense, wet,	4	11.	+	++	一'	
12	grated, medium dense, wet,			Ŧ		.	
	‡	1		‡			1
13	+ [][]			+			
	1.11.1			Ŧ			
14	工						1
					Ш		
PI	ROJECT NO. 89MC114A					•	SHEET OF 3

	woodwi	ard-Clyde Consultants The PROJECT A	GHAPI	HIC LOG	-	:	SA	MPLES	HOLE NO
	(1334) (1334)	DESCRIPTION	Lithology		Wete Conten	Piezones	Type Na.	The Part of the Pa	REMARKS  (Drift Mole, Fluid to
14		AME: 51 Hy SAND, five-grains poor/x graded, medium lense, wet, 10 yr 5/4 yellowish-brown	my 5 19				-	•	Alluvium
15	<u>‡</u> .	dense wet , 10 yr 5/4				-		+	-
•	Ŧ	yellowish - brown					25	13 9 19	De zoza
16	+ ω	ith some siltier zones						ji	5
17	=				1	=	-		
	. ‡				'				1.
18	+			1. / /	45				
19	1					=	-		
,,	‡						-		
20	<b>‡</b>	(11 11) -					- (	18 4	PIO=NI
21	= ~	it some thin seams (1/2") of ILT , 10 yr 8/3 very pale brown		17		-	.55 -	1	1
42	1 2			The same		]	- /		K WATER AD
22					7				AD
23	<u> </u>	1/	4111			-	-		<b>!</b>
24	1					-	-		.  '
	1					-			
25	‡		1111			1	-55	110	PID=ND
26	: S;	Ity copy a highly plastice hard ou	ets CH			1 4 .		59	SIFICATION
29	- (0^	The CAND five-grained poor/y	SM	1		-			Allwinn
27	+3	phovish bound with some 2,5 yrs/4	PILL			-			
28	tak.v	mothling					-		
	Ŧ	K 11 .							
29	+			•					
30	#					-	-55	# 527 7	PIO = 110
. 1	: ‡						-	14	
31	=								
32						-	-		SHEET

89 MC114A

PROJECT. NO.

SHEET 3 of 3

BODING LOCATION CITY SETTLING BASTAS  BORLING EXCENT CAPAGE LACESTS AND DIVERS ARRESTS ARRESTS AND CONTROL OF SETTLINGS (1) A 17 AND CONTROL OF SETTLINGS (1) AND	100		AME		I E L E V	A 1 I I U	N AND	,,,,	-	
CONTINUE COMP STATE STAT	DURING LOCATION CIWE SETTLING BY	57NJ.	4.	_						0/6-22-90
Continue to the second point of the second poi	DRILLING AGENCY CAYNE -WESTERN		YARKA	<u>-</u>	DATE	FHIL	SHED			
STEE AND TYPE OF FESTIVE  TITE AND TYPE OF FESTIVE  TYPE OF PRINCIPATION  TYPE OF PRINCIPATION  DESCRIPTION		DO HSH		-						
SIZE AND TWE OF PACK  STEE AND TWE OF PACK		Divide ove					5 (		10.5	COMPL 25.5 34 145 12
THE NO THEO OF PERCY   1904   10 - 11   10   17   10   10   17   17   17		45.000	10	FT.		_			10.5	
TYPE OF SEAL — GIBOUT 1900 D 9/7.5"  DESCRIPTION  SITURDISCOPPED  TO SITURD SAND, Fine grained growing to yearly  PLOSITE, SHIFT, Using moist trying to the property of the grained growing to yearly  PLOSITE CORY, low to medium plastic y  The string grained growing to yearly  DESCRIPTION  FILL  STORY DOWN to medium plastic y  TO SITURD SAND, Using fine grained growty  TO SITURD SAND, Using fine grained growty  STORY SITURD SAND, Using fine grained growty  STORY SITURD SAND, Using fine grained growty  STORY SITURD SAND, Using fine grained growty  STORY SITURD SAND, Using fine grained growty  STORY SITURD SAND  STORY SAND  STORY SITURD SAND  DESCRIPTION  ATTORY  ATTORY  ATTORY  DESCRIPTION  TO SAND SUM ATTORY  ATTORY  ATTORY  ATTORY  DESCRIPTION  TO SAND SUM ATTORY  ATTORY  DESCRIPTION  TO SAND SUM ATTORY  TO SAND SUM ATTORY  ATTORY  ATTORY  ATTORY  DESCRIPTION  TO SAND SUM ATTORY  TO SAND SUM ATTORY  ATTORY  TO SAND SUM ATTORY  TO				FT .				:csa	2772	
DESCRIPTION  DESCRIPTION  DESCRIPTION  DESCRIPTION  DESCRIPTION  DESCRIPTION  DESCRIPTION  DESCRIPTION  DESCRIPTION  DESCRIPTION  DESCRIPTION  DESCRIPTION  SITURD PROPERTY TO	SIZE AND TYPE OF PACK			ET	٥.	<b>,</b> ,	1161-	,,,,		
SILLY SAND, Fine grained - poorly graded to medicine to the source of th	TYPE OF SEAL - GROUT	THOM D-		_					04.65	
Silfy SAND, Fine spring poorly gread of silf / AIIE (SILF) Arg. 10 yes/6  Wellowish - brown  (a) Sand silfy CLAY, Bow to madring plastic, stiff, yeary moist, joyed/1  gray to light from Light trace of madring plastic, stiff, yeary moist toyed  Chips: They cray, low to madring plastic, stiff, yeary moist toyed  The sand silfy cray from a gray of silf spring silf town  Fill  (SM) Si Hus SAND, went fire grained growth or sand silfy silfy sand sold in lads c, bent sold moist toyed for sand silfy silfy sand sold in lads c, bent sold moist toyed for sand silfy silfy sand sold in lads c, bent sold moist toyed for sand sold in lads c, bent sold moist toyed for sand silfy sand sold in lads c, bent sold moist toyed for sand sold moist toyed for s	70		GRAIN			5	£ .	1	9-3-	
Silly SAND, fine quint growth great of silly sand of silly silly sand of silly sil	DESCRIPTION		Lithology		ation	şë Ş	8		2 2 2 2	(Drill Rate, Fluid loss, Odor, e
Silly shall strong to yes / 10	05 Cont		य । मा		-	-		-10	1	
medical day, 10 yes/6  yellowish brown  Wellowish brown  Wellowish brown  Fill study, 10 yes yes making played to the played to light your woist 10 yes/1  gray to light your with tree of medican gravely to light your to medican played, 10 yes yes olve gray to light your to medican played, 10 yes yes olve gray to light your to medican played, 10 yes yes olve gray to light your to lead so, on the same grave of the property of the same years of the years of the same years of the same years of the years of the years of the years of	+ SIHy SAND, fine grained , por	by gialed	NI	1	1		Ŧ	1		14 / 61/B)
(catsandy sitty CLAY, ) on to making plastic, strift, young moist, 10/46/1  grant to light grang with trace of making grant has some work to perform plastic, strift, young moist to per making strift, young moist to per making strift, young moist to per making strift, young moist to per making strift, young moist to per making strift, young moist to per making strift, young strike grant following sand/sith some sand/sith or sandy stllt dark grant strift, young strike grant strift, young strike grant strift, young strike grant strift, young strike grant strift, young strike grant strift, young strike grant strift, young strike grant strift, young strike grant strike strike strike grant strike st	I meliunderseg dryg 10	YR5/6	MM		1		Ŧ			3/* / / ~ (1)
(ST) Si Hu SAND, very five year property  The sandy SILT  (ST) Si Hy SAND, very five grained poorly  (ST) Si Hy SAND, very five grained poorly  To sandy SILT  (ST) Si Hy SAND, very five grained poorly  (ST) Si Hy SAND, very five grained poorly  The sandy SILT  (ST) Si Hy SAND, very five grained poorly  ST) Si Hy SAND, very five grained poorly  ST) Si Hy SAND, very five grained poorly  The sandy SILT  (ST) Si Hy SAND, very five grained poorly  ST) Si Hy SAND, very five grained poorly  The sandy SILT  (ST) Si Hy SAND, very five grained poorly  The sand five grained poorly	I T vellowish - Lrown				A	·	Ŧ			• •
Composition of the state of the		No. 1	TALK.	Ť Ì			#	1		Fill/Shules
Ships: Husando went five you ned good his stand of some work to yet of some work to yet of the sound of the s	fet sandy sity CLAY, low to	mediting.				ł	-14	9	100	1 / 5 / 2
medium gravel had some work  Chips  Fill  Composition street, very moist topy  The street of the grave	1	- 1071//	$\langle \cdot \rangle$	1			‡			
Composition states very moist tope  The sand, we have grained speech  States and site  The sand, we have grained speech  Toy and the sand state  The sand stat	I t going to light group with t	vec of	V		1		F	T	.,	
Colors: The color story town to medium plastics  Medium Stiff, very moist toye  25 yet along grand grand grand grand  Fill  (Sm) 5: Ha SAND, very fine grand grand grant  or sandy SILT  (Sm) 5: Ha SAND, very fine grand grant  or sandy SILT  (Sm) 5: Ha SAND, very fine grand grant  or sandy SILT  (Sm) 5: Ha SAND, very fine grand grant  or sandy SILT  (Sm) 5: Ha SAND, very fine grand growly  or sandy SILT  (Sm) 5: Ha SAND, very fine grand growly  or sand grand  SS	I melium growel and son	e work	1	-				٠,	Y9	PIO=ND
Fill  (ct)s: The copy, low to medium plastic,  medium street, very moist toyer  2.5 yr 6/N6 grand  Fill  (St) S: Hu SAND, very fine grand growth  woist, 10 yr 4/2 amb grang ist boom  or sandy SILT  (St) S: Hy SAND, very fine grained growty  (St) S: Hy SAND, very fine grained growty  for sandy SILT  (St) S: Hy SAND, very fine grained growty  for sand grand grand grand growty  SS 5 35 All with  All with  All with  All with  All with  All with  All with  All with  Brown	t chips	· 2	$Y \subseteq \mathcal{Y}$	4	21		#	7		
Fill  (Sm) Si Hu SAND, very five grained growth  woist, to ye 4/2 dark young ist brown  or sandy SILT  (Sm) Si Hu SAND, very five grained growth  or sandy SILT  (Sm) Si Hu SAND, very five grained growth  or sandy SILT  (Sm) Si Hu SAND, very five grained growth  forward  (Sm) Si Hu SAND, very five grained growth  forward  grained growth  Alluwing  SST 2  Alluwing  Alluwing  SST 2  Alluwing  Alluwing  SST 2  Alluwing  Alluwing  Alluwing  Alluwing  SST 2  ATD  PID=ND	# 5:1/	•		1	- 1	- 1	+	_	-	
Fill  (Sm) Si Hu SAND, very five grained goodh  or sandy SILT  (Sm) Si Hu SAND, very five grained goodh  or sandy SILT  (Sm) Si Hu SAND, very five grained goodh  or sandy SILT  (Sm) Si Hu SAND, very five grained goodh  or sandy SILT  (Sm) Si Hu SAND, very five grained goodh  or sandy SILT  (Sm) Si Hu SAND, very five grained goodh  or sandy SILT  (Sm) Si Hu SAND, very five grained goodh  or sandy SILT  (Sm) Si Hu SAND, very five grained goodh  or sandy SILT  (Sm) Si Hu SAND, very five grained goodh  or sandy SILT  (Sm) Si Hu SAND, very five grained goodh  or sandy SILT  (Sm) Si Hu SAND, very five grained goodh  or sandy SILT  (Sm) Si Hu SAND, very five grained goodh  or sandy SILT  (Sm) Si Hu SAND, very five grained goodh  or sandy SILT  (Sm) Si Hu SAND, very five grained goodh  or sandy SILT  (Sm) Si Hu SAND, very five grained goodh  or sandy SILT  (Sm) Si Hu SAND, very five grained goodh  or sandy SILT  (Sm) Si Hu SAND, very five grained grained goodh  or sandy SILT  (Sm) Si Hu SAND, very five grained grai	1 + 111		I X	100			1	1		
Fill  Styl situs AND, very five grained growth  world, near the grained growth  or sandy SILT  Styl Sith SAND, very five grained growth  or sandy SILT  Styl Sith SAND, very five grained growty  granted, loose, wet, loyes/2 granty  brown  SST 2  Alluwing/Estim  SST 3  PID = ND  Alluwing  Condor and as  ATD  PID = ND	1 A = - =	1.450	7.7	P	- T	٠. ا	Ŧ	1		Sludge:
(Sm) Si Hu SAND, very fine grained good by the sandy SILT  (Sm) Si Hu SAND, very fine grained good by the grained growth or sandy SILT  (Sm) Si Hu SAND, very fine grained growth the gr	CES: Ty coay 2 100 to mest	to VE	/	Ì	1	2	+	+		
(Sm) Si Hu SAND, very fine grained goody  moist, 10 ye 4/2 dark gray ish down or sandy SILT  (Sm) Si Hu SAND, very fine grained goody  (Sm) Si Hu SAND, very fine grained goody  Brown  (Sm) Si Hu JAND, very fine grained goody  SSF 2  ATD  PID = ND	median string	( )					+	L	12	DEVEND
(Sm) Si Hy SAND, very five grained growth worst loye 4/2 dank gray ish town for sandy SILT  (Sm) Si Hy SAND, very five grained growty  (Sm) Si Hy SAND, very five grained growty  grantle, loose, wet, 1048/2 grayist  brown  Si 2  Alluvian/colian  Su-0/siH  So 3  Alluvian  Si 4  Alluvian  Si 5  Alluvian  Si 6  Alluvian  Si 7  Alluvian  All	1 + 25 y = 1/20 8 . 8	16	7	-	7	- 1	Ŧs.	5 6	13,	P#0
SN) Si Hy SAND, very five grained poorly  Sn) Si Hy SAND, very five grained poorly  brown  SSF 2  ATD  PID=ND  Allowin  SSF 2  ATD  PID=ND	1 <del>T</del> ~.11	1.1				ı	7		7	· · ·
SM) Si Hy SAND, very five grained poorly  Sind Si Hy SAND, very five grained poorly  Shown Jose, wet, 1048/2 grajel  Step 2  ATD  PID=ND	1 # FIII	/ 4	X			-	-	1		
SM) Si Hy SAND, very five grained poorly  Sind Si Hy SAND, very five grained poorly  Shown Jose, wet, 1048/2 grajel  Step 2  ATD  PID=ND			717	-		- 1	+	.		1-1-
SM) Si Hy SAND, very five grained poorly  Sind Si Hy SAND, very five grained poorly  Shown Jose, wet, 1048/2 grajel  Step 2  ATD  PID=ND	(STATS: Hy SAND, very five grun	or showly	711				‡_	$\perp$		Allwin / Golish
SMIS: Hy SAND, very fine grained poorly  grand, loose, wet, 1042/2 grand  brown  SST 2  ATD  PID=ND  ATD  PID=ND	of gratel, meditanders co	benz	1341				#	Т		Sand/sitt
(SM) Si Hy SAND, veny fine grained growty  SM) Si Hy SAND, veny fine grained growty  Brown  SST 12  ATD  PID=ND	- mois , i ) - 1/	r-promu					+-	جل	30	DTD=ND
(Sm) Si Hy SAND, very five grained, poorly graphed, loose, wet, 10485/2 graphed brown  ST 3  PID=ND	tor sandy SILT		4 5 1				٠٠	٦	3	PID
brown  STATE  ATD  PID=ND			1-1-1				Ŧ	1		
brown  STATE  ATD  PID=ND			1 .				Ŧ	T		
brown  STATE  ATD  PID=ND	the same and armine	DON LY				١	‡	1		ALL .
brown  STATE  ATD  PID=ND	(Snt) Si Hy SAND) 2007 1 8	12 Avenily	1-1			-1	-‡-	+		HILIWIN
STATE PID = ND	I gimen, 100,00	129.2	1.1-1-1				‡	-	1	Lwater ender
	I brown		1171				10	SF	2	ATD
							+		3	PID=ND
					l	- 1	<u>+</u>	+		
			18			ı	土			
	[ <del>+</del>		11.11			- 1	Ŧ		-	
	1		114.			- 1	ŧ			•
	1 ±		1111				士			
	<u>.</u>						Ŧ			
	1 ‡		1 1				· ‡			
	l I		1111				_4_			
(0111/)			11.11.							
										/

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Woodward-Clyde Consultants The PROJECT NAME HOLE NO. GHAPITIC LOG REMARKS Weige Content DEPTH (FEET) DESCRIPTION (Dritt Role, Fluid less, Odor, etc) SAME: Silty SAND, very fire-granted poor ! graftly in blis um losonice, poor! 1098 4/3 brown to don't brown allering Denwar Fri 33 CLAY SHALE: SIHY CLUAY, medium to highly plastice, have, brown with true of fire grane DIO= ND SAND, blocky texture stoffed do: 11ing 35 33 Claystone 50/ resumed duilling 36 6-22-90 WEATHORED SHALE: silty cray highly plastic, hard overy moist a loyald !!

light ground of ground with iron oxide

- strining and iron modules west Denver for 3 38 claystone 39 are rum #1 40 12 - WEATHERED SANDSTONE SITY SAND, for a grained spoorly angely work, 10 yr 7/ Demer Fu Denver Fr light gray in plastic shard, very woist, 10 yr 6/1

- 11/1 + gray to gray with irm oxide

staning and irm nodules clayston 13 everun#2 Dewer Fm CHI SHALE: SITY CLAY, Lighty plasticg. hard, very wrist, 10 yr 4/1 lank gruy with trace of fine grained sity strop seams, 10 yr 4/1 light gray Claystone Botton of boin at 47.5 feet 89m4114A SHEET\_

DOWNEL EXCENSIVE LIMITE SETTING BASINS  SHILLING EXCENSIVE MY SETTING DISTRIPT OF PROPERTY OF SETTING	Voodward-Clyde Consultants PROJECT NAME	10	OE	<u>D.</u>	0.	1_	HOLE	NO. 151
MILLING LIEUTON HOLLOW STEPN AMBERS   DURLL BIT    MILLING LIEUTON HOLLOW STEPN AMBERS   DURLL BIT    MILLING LIEUTON HOLLOW STEPN AMBERS   DURLL BIT    MILLING LIEUTON HOLLOW STEPN AMBERS    MILLING LIEUTON HOLLOW STEPN AMBERS    MILLING OF PRACK    MILLING LIEUTON HOLLOW STEPN AMBERS    MILLING LIEUTON    MILLING LIEUTON HOLLOW STEPN AMBERS    MILLING LIEUTON    MILLING LIEUTON HOLLOW STEPN AMBERS    MILLING LIEUTON    MILLIN	JOHNING LOCATION / IME SETTLING BASINS		ELEVATIO	NA NO	DAT	UM .		. 4
DIRECTOR CONTRACT CAMES STATE GOODS WITH A CONTROL OF THE CONTROL OF CAMES STATE STA		4	DATE FM	ISHED				1.20
DIRECTION HOLLOW STEM ANGOLS  DIVILLE AND TYPE OF PACK  TYPE OF PERSONNELL  DESCRIPTION  DESCRIP	DHILLING EQUIPMENT CIMESS WITH 6-5/8" HSA					A 1.0		+ spoon
THE OF PERFORATION   PROM   10 FL LOGGED BY   CHECKED BY    THE AND TYPE OF PACK   PROM   10 FL    THE AND TYPE OF PACK   PROM   10 FL    THE AND TYPE OF PACK   PROM   10 PL		SAMPLE	5			<u> </u>	124-1195. (	
THE OF PERSONATION  DESCRIPTION		ELEV		FIRS	13	1/	STRU	
THE OF SEAL — GROWT PRODUCT TO A SECTION OF THE OF SEAL DESCRIPTION    Committee Code   Committee Code   Committee Code   Committee Code   Cod	THE OF PERFORATION		LOGGED	UY				• • •
DESCRIPTON  Limitagy enteromates and provided on poorly growth, meltium dente, pade to provide by not the melting provided on poorly growth brownishing provided by not the melting provided brownishing provided brownishing provided brownish provided brownish provided brownish brownish provided brownish brownish provided brownish and becomes very moist  Lith some 3: If i'm your specific brownish brownish and becomes very moist  SS 16 13 PTD = ND  Distorrements are the provided brownish and becomes very moist  Distorrements are the provided brownish and becomes very moist	IZE AND TIPE OF PACK		S.W	DRA	275	SETTE		
Ellindry ministration 25   SIN 19 PID=ND  (Sm) Silty SAND, fine-grained, poorly dry, 10 ye blo brown: SL-yallow  SSIN 19 PID=ND  (Sm) Silty SAND, fine-grained, poorly  SSIN 19 PID=ND  (Sm) Silty SAND, fine-grained growly  SSIN 19 PID=ND								
(Sm) sity SAND, fine grained, medium dente, dry, loyeb/6 brownist-gallow  with some loyes/1 white mottling  SSIN 1/9  FID=ND  SSIN 1/9  FID=ND  Allwinn  tolomohomigs to toyes/8 promist  brown, and becomes very moist  color changes to loyeb/8 brownish  color changes to loyeb/8 brownish  cyellow, and becomes very moist  SSIN 1/2  PID=ND  Dente of the some states of the some	T.C.	T.		10.	9	=   4-1}-	7	IARKS.
SSIN 19 PID=ND  SSIN 19 PID=ND  SSIN 19 PID=ND  SSIN 19 PID=ND  SSIN 19 PID=ND  Allowing  Color changes to loye 1/8 brownish- cyclor, and becomes very moist  cyclor, and becomes very moist  Color changes to loye 1/8 brownish- cyclor, and becomes very moist  Distriction, and becomes very moist  Distriction of the color of the col	DESCRIPTION LINDOGY		eler 3 €	28	1	Penet Resident		
	with some loyes/I white mottling  (sm) Sitty SNNO, fine—animal, growly, groundly ynthings during, groundly ynthings during, tolon changes to toye 5/8 yellowish brown, and secones way noist  with some sittier zones color changes to loye 6/8 brownish- egollow, and becomes very moist			+	221	9 65.55	PID=	2D
	OJECT NO. 89MC114A		<del></del>				SHEET_	Lora

A22-20

PROJECT NO. 89MC114A

29.

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SHEET 2 OF 2

Bottom of being at 29.5 FRET

ORING LOCATION	Sec	36				ELEVATI	- A		10.		**
RILLING AGENCY			DRILLER	RIMO	Carl	DATE S	ARTE	3	6/:	25/90	7
RILLING EQUIPMEN	Layne	Western		DIME	YMY	COMPLE			" 38	SAMPLER J	Terry
HILLING METHOD	LIVE	<u>- 15</u>	TORILL I	iit		NO.	OF	DIST		UHDIST.	
		Stem				WATE		FIRS	13 ft	COMPL	24 IRS.
ZE AND TYPE OF	7	in PVC	!FROM	10. 10.	2 FL	LOGGED	v	<u> </u>	1576	CHECKED BY	
PE OF PERFORAT	10	56t		18 102					1/		• • ••
ZE AND TYPE OF	PACK /C	1-20 Sang		10	23 FT.	1.	Te	"	y		
PE OF SEAL	· Be	ntonite	FROM	11 10/	3 <sup>F</sup>						
	_			GI	APHIC LO	)G	3	54	WPLES	PID	PPM
<b>E</b>	i	DESCRIPTION		Lithok	gy Pleto	etion	200	2	Penetr Reset Boss	(Drill Rate, Fig.	ild loss, Odor, o
5			• .				ā.	1774	5 5 5 3 6		
+ Grav	el san	dy, dry, d	ense.	10 3	2	1.1					· .
F	ch las	10 5 13 1	C.P)							i	
# \ Dion	1,10	YR5/3 (				M -	1 -				
#	, ,						1 1		100	The second	
+ Sur	id, dr	y to sligh	ntly mois	t,		$\mathcal{V}$	1			$\mathbb{R}^{J}$ .	
+ 1005	e to m	edium dens	sé nedi	um .		M .	7	-	· ·		
t . + . f	ina ==	1 1	1 11			1)	1 1		1-		
I Lo	me sai	nd, brown us to 10 Y	on yellor	7			1	: '	5	N	D
T 10	YK 5/3	3 to 10 Y	R 4/4		N	13%	1	. }	4.	/V	y
‡ ( <i>s</i>	9-) · 5	ilty	•	1	7	1/1	ΙŦ		4	6 V	
± 5N	1	· · ·		• **	1	X	-	-			
±				/ \		)15.	‡				• '
Ŧ			•		1/-	( )	1	:		0 -	
干		*	-	1:		/	-	-	3		
#				Same of the same	7	4	+		4	. N	$\mathcal{D}$
# _			مم	din	7	12	Ŧ		1 4	. /• .	•
+ (1)	W la	LOW Sand	d. mediun	1 16	$\mathbf{N}$		7		13	•	:
± 3/19/1	ny and	d, dense,	1	1.3	(1/1)	(1 1	Ŧ				
+ 70+	ne san	a, acrise,	Drawns	11/6	1/1		-‡-	-			
+ ye	low (-	54) 10 YR	177	137	25		#				
Ŧ	5,	Ity //		1.	A)		#		8	NIT	
‡		1.11	-				+	-	14	-NL	<b>/</b>
‡		and the second	1	-1	1/1		+		1:21		•
<b>‡</b>			1	1	1/1		Ŧ	- 1	13		
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±	•	Samuel Contraction of the Contra	" The same of the	1 , 1		C	‡		1 1		,
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<b>+</b>	2.4			1.	1	1	+		1 1	Bentonit	e <sub>.</sub>
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				1/'							
		9 89MCI	1 / 1 A							SHEET_	1 7

A22-22

7.5	1:	GRAPH	IC LOG	. =	<u> </u>	SAM	PLES	PID PPM
OCPTH (FEET)	DESCRIPTION	Lithology	Plesometer tectolistics	Conte	Dot	1000	Peretta Blown Friend	(Driff Role, Fluid less, Odor, etc.)
14 - 15 - 16 -	Clay, Sandy, medium to fine sand, wet to moist, stiff, Olive to light olive brown, iron oxide staining, layered (CL), \$\sim 5\con 5/4,  2.5\con 5/4				100011000100010		5910	ND
18- 19- 20-	clayey Sand				***		m 00	3, 0
21- 22- 23- 24-					+++++++++++++++++++++++++++++++++++++++		11	
25 26 27	Clay, slightly sandy, v. moist to dry, color varies from very palebrown to dark brown, medium stiff to stiff (CL)		grout		****		<i>5</i> 7 8	ND
28 29 30	weathered Claystone, stiff to very stiff, moist to dry, pale olive \$7673 to olive gray, blocky, crumbly, (CH)				**		6 13 12	· N.D
3Z-	gray, blocky, crumbly, (CH) - 54 6/3, 544/2 TNO. 2050 89MC114A				‡			SHEET 2 OF 3

Woodward-Clyde Consultants 🖼 P	ROJECT I	NAME _	<u></u>	OF	1).	.0.	<u></u>	HOLE NO
BURING LOCATION LIME SETTLING BA	ELEVATION AND DATUM							
UNILLING AGENCY LAYNE-WESTERN	DAILLENY-	4 Britton		DATE ST	ISHED	- /	-3-9	
DHILLING EQUIPMENT CATE 75 W/6-5/8"	HSA			COMPLET				SAMPLEN3" Split you
DHILLING METIND HOLLOW STEM AUGERS	DRILL BIT			NO. (	5	DIST.		UNDIST.
SIZE AND TYPE OF CASING				WATE	•	FIRS	7.0	COMPL ND 24 HHS.
TYPE OF PERFORATION	FROM -	10	FY.	LOCCED	BY			CHECKED BY
SIZE AND TYPE OF PACK	FROM	10	£1.	S.W	ORI	Ris.	SETTE	, ••
THE OF SEAL - GROUT	FROM	1031.5	- **					
DESCRIPTION OF SECURITION		Lithology	IC LO	meter Karier	Pleason ere Cate	Tre Re	Perstra Resist (Brestra (C)	REMARKS (Drill Rate, Field loss, Odor, e
Sm) silty SAND, fine quained  becomes very moist and low very loose  (Sm owned) Silty SAND on simply very loose, fine quained, yearly very loose, wet;  s/3 brown,  becomes loyes/1 gray  Secomes loyes/1 gray  becomes loyes/1 gray  oyre/2 light brownish-que  loyes/2 light brownish-que	out to						97716 2-3	PID=ND  Allowium water autors ATD  PID=ND  Allowium PID=ND
<u></u>	*							
JECT NO. 89MC/14A								SHEET LOF

		JECT NAME	PHIC LOG	- E S	AMPLES	
XE .	DESCRIPTION	Litholog	Merometer Installation	Weise Conten Con	ALLER S	REUARKS (Orill Rale, Field less, Ode
	11 caro Con - 1 - 1 - 1 - 1	0		* 5 E	2 2 200	
17 7 (SM)	5: Hy SAND, firegraine, rull, medium duse	2900019	11 1	1 =	11 1	Alluotum
15 ± 9	rolled medium duse	-) 18/5/3 [ -	1 1	1 ‡		
1'' Ŧ "	prown	11111		1 7	5	
\ \ \ \ \ \ \ \ \ \ \ \ \ \ \ \ \ \ \	•	11-1-1-1		22		DIO=ND
1/6+		11111	.1	1	15	•
I	4			1 1	1	
17+		- 1-11-1-1		1-1-1		
· ‡		· [H]		1 E 1		
18-		1-1,1,1-1,	; 1	1/47	1 1	
I	. *	11111	$\vdash A$	1 FN		*
19 F.		]	1 1	1 7	The state of the state of	>
I/CL) so	ordy 3: Hy CLAY, low to me stic, stiff to very Stiff, ve st, loyellf dark yellowish of grained SAND	ed:um :	1	1 = 1	1 1	Haring
pla:	stic, stiff to very Stiff, ue	ry	1/		r	Ilmium eworked shale
20 - moi:	st, loye 4/4 dave yellowsh i	, ( ···		1 1		•
I 41~	- Au			±55/13	59	PID=3ppm
77	•	- 1 3	~ 1	+	111	•
<b>.</b>	•	1. 1.	1965 TO 1965			
22-1-	•	.:.		1-1-1		<i>i</i> •
#		· iee		Y		
23 7011 8:1	Le clase SHATE highly do	4:0		±	10	Eu
vev.	ty clay State, highly play stiff, very mist, 2-546, + yellowith - brown	14		1 # 11	1.0	enver Fm: entherel
29-1- ligh	+ yellowith - brown	<i>''</i>	1	- -		
·r	aclay Stone			🗜		*,
25				1		•
. ‡				# 1	2	,
, ‡				:55 12	<i>''</i> 1	IO = 34 ppm
o I			1 1	Ŧ	13	
			.	<b>!</b>	- a	re run#1
7-]-				- <del> </del> -c	1	
,Ŧ,	1 1			+011		
8-1-becoming	less weathered					ĺ
‡				ccs		
9				147		
T (P 41) S; Hu	siff to havel, very moist			†	De	enver Fm.
- loyes	11 gray to loye 2/1 very dark	2				
7 gray	iron oxide stains, avagent	te		+		1
cvy stal	S THE STATE OF THE			<u> </u>	1	1
+	Claystone			<u> </u>		
· ·				1	Ballo	n of boring

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Wood	dward-Clyde Consultants ( PROJECT NAM	E	BE I	٥,٥		2_	· .	_ HOLE NO. LSB-
OEPTH (FEET),	DESCRIPTION		Plezameter Installation	Woi e F	Figurater Defa		MPLES	REHARKS (Orth Refe, Fluid lass, Odor, et
14-	SAME: (sm) si Hy SAND, fire to				•	-	·	Allunium
R	SAME: (sm) si Hy SAND, fine to medium grainel, poorly gradely donse, wety loyes/2 grayis( - brown					55/	11 16	P=0=627ppm
16	becomes loyes/3 brown with loyes/1 quay mottling				-	37	24	
17	(ML) SILT , mon-plastie, stiff to					- 7		Allwinn
18	levy Stiff, very moist to be 3 10425/3 brown will trace strong five sand and iron oxide strins Clay, low plasticity				#		-	
19 <del>I</del>					+	-	at by Control	
20-	-					SS 17	4 10	p=0=114
21 +			~ /			,	-"	,
3					#			
#			1		#			S. Gu
\$\frac{1}{4}	(CL to SC) sanly si Hy CLAY to clayey?  SAND, low to medium plastic guery  SHIFT very moist, 10485/3 brown				#	- -	,(	Allwium Vewsrkel Shale
) <del> </del>	Stiff ven moist, 10485/3 brown with 10488/1 white mothling				15	SIA	10	PI0=81Pm
7					+			
X = 7.	CH) silly clay SHALE, have, highly				+		1	Januer Fm.
7	plastic, very moist, 10 yr 5/2 grayish- brown with thin fine grand short seams, ivon orice stains, and blocky				+			WEATHER ED
· L	texture, corbonaceons leathered laystone			.	S		1	p=0=124ppm
/-					CC	#	34	iore run#1
-1-	NO. 89mc114A					Ш_		SHEET 2 OF 3

	dward-Clyde Consultants (III) PROJECT NAM			-				ce		
DEPTH (FECT)	DESCRIPTION	,Lithology	Plezameter Ineselletion	Wete r Content	Pktoneter Deta	Type HE	Feer. (1)	1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1	REMARKS (Dritt Role, Field Sees, Odor, etc)	
32-	- SAME: (CH) silty clay states, hard, highly dustics very moist, 10y25/2 grayish - brown with thin fine and MNO seams, iron ovide stowns, med blacky Lexture, carbonalous				-	-	П		core run#1	
70	SAME CAT STICE very moisty			1	1		Ш		Denver Fm.	
77	high of passed hown with				:		Н		WEALHELED,	
33-	10425/2 grapes soms						身			• .
-,7	thin time they and blocky				#	cc	4	-		
34-1	texture, carbonacous			- 1		-			•	
1					#					
35	weathered Claystone			.	_		- -		- 40	
?'Ŧ	(CH) sitty clay States hard, highly plastic, very moist, 10 ye 4/2 dark avery ist-brown, iven oxide string, carbonaceous, becomes 1242 2/2 very			ł		:/		- 1	Cove run#2	
• ‡	plastic, very moist, 1042412 dave				1			ı	Denver Fm	
36-	year ish-busing iven exide stains g				+	-	1	- 1		
#	dark brown at 36 FEET			- 4	1				Sean of while	•
_‡	and Dade Gray		i		+	CC	d .	7	rystalline motoral	
7‡	- becomes loyed/ lank group		. [		7	-	4		at ~ 37 FRET	
+	Claystone				Ŧ		T			
8#	<u>'</u>		1/ 1	- 1	-	- 1				•
Ŧ			( ·		‡				•	
$^{\ddagger}$	- becomes 10 yRG/1 light gray to gray		-/1		#					
9‡	- becomes to year in 1 1 1.	-	1	- 1	Ŧ		Т	$\neg$	Borron of Boring	
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	NO. 84 MCILLA								SHEET JOE J	•

SHEET\_

JUL 2.5 1990 HOLE NO. LSB-19 COE D.O. 1 Woodward-Clyde Consultants PROJECT NAME TOURING LOCATION ! :MP Settling DATE STARTED 7-12-90 DRILLERM. Walker 7-11-90 DRILLING AGENCY LAUNE-Western SAMPLER3" SOI + SPOOM COMPLETION DEPTH 29,5 MENT CLUE 750 W/6-5/8" DO HSA UHILLING METHODHOllow Stem Angers WATER ELEV. CHECKED BY LOGGED BY LEROM TYPE OF PERFORATION TO SIZE AND TYPE OF PACK FROM . S. MORRISSETTE FROM O 10,99,5 TYPE OF SEAL GROUT GRAPHIC LOG DEPTH (FEET) REMARKS DESCRIPTION 3 (Drill Rate, Fluid loss, Odor, etc. dedian soul/silt (Sm) slightly clayey silty SANO, fine , poorly graded, medium dense, moist, 10 yrs/3 brown, upper 6 inches gravelly 5 PID = ND 3 3 Allavium SAND of the gra moist, loyes/3 brown 34 DID=ND SS (5m) sith SANO, fine grainal, poor /v gradid, very dense, moist to very nusist, 10 yes/f yellowish - brown Allwium 12 8 PID=ND 20 31 Allwium water enters ATD 12 155 K 11 DID=ND 11 11 13 water @ 14.0 on drill rols us acco on 7-12-90 89mc114A OF 2

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PROJECT NO.

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OCPTH (FEET)	DESCRIPTION	Lithology	Plezomeler Instelletion	Wo: . Confe	Pieton	ype M	1000	THE STATE OF	(Oritt Role, Fluid Sess, Oder, at
-	The second of the second Grant	ZELZ		_				-	Allwium
4-	- SAME: (se) silty days sand, fine-				:		П		,
-	(SM) grained, poor of groded, medium	1			l t		П		·
5-	Lense, moist, loyes/3 brown	1-1/1			-		Н		1
ď		MHIM			1		П	7	
3		11/11			. 7	SS	18	10	PID = / ppm
16-	<u></u>	ити			7	-	П	12	
1					4	_	Н		<b>!</b>
	•	n fui		İ	A	- >1	H		'
7+	(CL or SC) Sandy sity clay or clayers  SAND, very stiff, low plastic, very				/4	7			Allwium / Denver
. 7	(CL or SC) Sandy James of			1	4				
	SAND very stiff, low plastic, very		1	1	7				Fm.
8-1	moist, loye /2 grayish-brown to	·/·	1	1	7		1		·
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1	10/28/2 white	15%	4		+	. [	4	10 mg	1
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+	- with some hard, blocky shale struting at 80 feet	7	/	1	Ţ		1	•	
07	- with some haves or and	· · · · /	İ		#	_	7		Denver Fm.
1	struting at 80 teet				+		-	"	wenthered
1		1/2	II		Ŧ	SS	7	15	DID = ND
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2-	-	2	$\sim$	7	) Ŧ		1		2 Mens Lecond
Ŧ	. /			V	#		1		Drilling becomes
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3 ∓	(CH) silty clay SHACE, highly plustice		_ ]	- 1	<b>±</b>	1			Denver Fri
士		<del>/ /</del>	~		+		1		
4	hard, very moist, loyp6/2 light	1		İ	#	.			
7 🕇	brownish-gray	<u> </u>	- 1		<b>±</b>				
+		1	- 1		Ŧ	1			
-Ŧ	claystone	7	- 1			+	+		week paitfue resum
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HOLE NO. LSB-020 Woodward-Clyde Consultants PROJECT NAME RMA COE DORING LOCATION DRILLER K Cross arne Western DRILLING AGENCY COMPLETION DEPTH DRILLING EQUIPMENT UNDIST. NO. OF DHILLING METIND Hollow Auger 24 1013. COMPL WATER . LOGGED DY CHECKED BY FHOM TYPE OF PERFORATION SIZE AND TYPE OF PACK T. Terry 10 30 TYPE OF SEAL Grout GHAPHIC LUG DESCRIPTION (Drill Rate, Fluid loss, Oder, etc.) Clay, very sandy, silty, fine sand, moist, stiff to very stiff, yellowish brown 10YR5/4 (CL) 8 12,6 9 9 13 6 16 Sand, silty, clayey, medium to fine sand, very moist to wet, medium dense to 0.2 в 6 dense, yellowish brown to brown 104R5/4, 10YR 5/3 (=P, SM) 10 3 32.9 4 11 12 12. 13

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A22-32

89MC114A

PROJECT NO.\_

SHEET 1 OF 2

		GHAPH	ic LOG	.=	ž  -	SAM	PLES	ecusare .
PET THE	DESCRIPTION	Lithology	Plezameter Inetalletion	Wo'e	Pictome	Acor.	ANTE SECTION	REMARKS (Drill Role, Fluid Issu, Odor, etc.)
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15-					‡	4	_	
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	Clay year sandy stiff	17.			重		, -	
17-	Clay, very sandy, stiff, very moist to wet, very			1	#			
18	dark grayish brown,				#			•
	10 YR 3/2 (CL)			á .	1	7	1	
19					‡			)
		///	<i>(</i>		‡_			·
20-		١	$\wedge$		‡		6 16	47.4
2/-					‡		27	
	weathered Claystone, sandy, moist, stiff to very stiff,	/	A Same		<b>F</b>	11	-/	
22-	pale brown, blocky				Ŧ			$\dot{r}$
23-	10YR6/3 (CH)	/			Ŧ			
		7/	~	1	‡			
24					‡	$\ $	•	/
					<u>‡</u>		ı	
25-					ŧ	Ш	9	51.6
26-	Claystone, moist firm,				‡	$\ $	14	
	pale brown				F	$\  \ $	20	
27-	- 10YR 6/3 (CH)				tc	$\ $		5.7
					10			
28-			.	-	‡K F	$\ $		
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או.חמת	T NO. 89 MC114A							SHEET Z OF Z

DRING LOCATION LINE SETTING BASINS  RILLING BERNET LANGE - WESTERN DIFFERENCE DIFFERENCE OF THE STREET TO 10 WIS STREET TO 10 WIS STREET TO 10 WIS STREET TO 10 WIS STREET TO 10 WIS STREET TO 10 WIS STREET TO 10 WINDS. I WHILL BIT SINGLE OF THE STREET TO 10 WINDS. I WHILL BIT SINGLE OF THE STREET TO 10 WINDS. I WHILL BIT SINGLE OF THE OF FACE FROM 10 FT. SMOOLES FOR THE OF FACE FROM 10 FT. SMOOLES FOR THE OF FACE FROM 10 TO FT. LOCKED BY  WE AND TYPE OF PACE FROM 10 FT. SMOOLES FOR THE OF SEAL GRANTS.  WE AND THE OF PACE FROM 10 TO FT. SMOOLES FOR THE OF SEAL GRANTS.  WE AND THE OF PACE FROM 10 TO FT. SMOOLES FOR THE OF SEAL GRANTS.  WE AND THE OF PACE FROM 10 TO FT. SMOOLES FOR THE OF SEAL GRANTS.  WE AND THE OF PACE FROM 10 TO FT. SMOOLES FOR THE OF SEAL GRANTS.  WE AND THE OF PACE FROM 10 TO FT. SMOOLES FOR THE OF SEAL GRANTS.  WE AND THE OF PACE FROM 10 TO FT. SMOOLES FOR THE OTHER STREET TO THE OF SEAL GRANTS.  WE AND THE OF PACE FROM 10 TO FT. SMOOLES FOR THE OTHER STREET TO THE OTHER S	Woodward-Chyde Consultants PROJEC	T NAME	Col	<u> D.</u>	ð	7	HOLE NO
MILLING BERNOT CAST (ST. 1975) W/6-5/8" MSA  MILLING BERNOT CAST (	JORING LOCATION LIME SETTLING BASINS	S					·
MILLION DETINOS DONAL STATE GRAPHERS DUTILL DIT SOLUTION STATE OF PERSON OF	RILLING AGENCY LANGE - WESTERN DRILLER	RM. WALKE	DATE	FWISHED			
EARD THE OF CAME  DESCRIPTION	Long Long Long Long Long Long Long Long	41.4.T				50.5	
THOM TO PE COORDINATION  THOM TO PE COORDINATION  THE AND THE OF PACK  THOM TO PE SAME  THE OF SEAL  OFFICIAL PROM TO PE SAME SAME SAME STATE  THE OF SEAL  OFFICIAL PROM TO SO, STATE  THOM TO PE COORDINATE OF SAME SAME SAME SAME SAME SAME SAME SAME	Hollow Ster angers	W11	SAM	PLES	i .	0.5	COUPL //  25 HISC
EE AND TIPE OF PACK  FE OF SEAL  DESCRIPTON  DESCRIPTO	CONTINUE SETTLING BASINDS  GRACIER LAME - WESTERN  GRACIER LAME - WESTERN  GRACIER LAME - WESTERN  GRACIER LAME - WESTERN  GRACIER LAME - WESTERN  GRACIER LAME - WESTERN  GRACIER LAME - WESTERN  GRACIER LAME - WESTERN  GRACIER LAME - WESTERN  GRACIER LAME - SON GRE CONTRIBUTION  GRACIER LAME - SON GRE CONTRIBUTION  GRACIER LAME - SON GRE CONTRIBUTION  FELLOWER OF PACK  FROM D 10 FT. LOGGED OF  FROM 10 FT. LOGGED OF  FROM 10 FT. LOGGED OF  FROM D 10 SDSTT  FROM						
DESCRIPTION  REMARKS:  REMARKS: REM	THE OF TENTONICION _		FT. C 1		-	1172	
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DESCRIPTION  Limited Planes of the Change Silfy power of the Short Silfy power of the special provided power of the special provided power of the special provided pr	4 Pour			15.7	SAM	PLES	
SM SAND, five grained goody -  (SM) Silhy SAND, five grained spoody -  (SM) Silhy SAND, five grained shop,  Sandy Silt brown  Sandy Silt SAND, five grained shop,  (SM) Silhy SAND, five grained shop,  gradia, prediction and shop,  SSB 7  All with an application of the grained shop,  gradia, prediction and shop,  SSB 7  All with shop five grained shop,  gradia, prediction dense, weet,  gradia, prediction dense, weet,  gradia, prediction dense, weet,  gradia, prediction dense, weet,  gradia, prediction dense, weet,  GM) Silhy SAND, five grained grootly-  gradia, prediction dense, weet,  gradia, prediction dense, weet,  gradia, prediction dense, weet,  GM) Silhy SAND, five grained grootly-  gradia, prediction dense, weet,  GM) Silhy SAND, five grained grootly-  GM All with an application dense granted grootly-  gradia, prediction dense granted grootly-  GM All with a sand granted grootly-  GM All with a sand granted grootly-  GM All with a sand granted gra	DESCRIPTION		Classic	Pleabor Dete	Type No.	Paratra Beriet E In	1
(SM) Sith SAND, five grand goods  SSIE  SSIE  PID=ND  And in smb/s  PID=ND  SSIE  All union  SSIE  All union  SSIE  All union	(Se) shiftly thought to daying silt	4					Road fill
(SM) Silly SAND, five grand goods.  (SM) Silly SAND, five grand shop  (SM) Lense of the grand shop  SSIB 2  SSIB 2  SSIB 2  All wines  (SM) Silly SAND, five grand goods.  (SM) Silly SAND, five grand goods.  (SM) silly sand, five grand goods.  All wines  All wines  All wines  All wines  All wines	graded, medium dense, moi	<b>4</b> ,			-		3
(Sm) sith SAND, five grained growth is a party of the sample of madium dense graded growth is a party of the graded samp, with a party of the graded samp, with a party of the graded samp, with a party of the graded samp, with a party of the graded	‡				SSIL	10	PID=ND
(SM) Silty SAND, five-another poorly-  gradle, medium dense, weet,						9	
(SM) Sith SAND, five-grand poorly- gradle, medium dense, wet,	= (Sm) sity SAND, fine grained good graded graded madium dense graded	5		1 ‡	CS is	4,	Destin Soud/sit
(SM) lense, v. fine grained shop, wet, loyer/3 brown, Sandy Silt SAND, fine-grained, poorly-  (SM) Silty SAND, fine-grained, poorly-  gradle, medium dense, wet,	10 yr 6/4				33/16	3	
(SM) lense, v. fine grained shop, wet, loyes/3 brown.  Sandy Silt 2  PID = 4 PPM water noted a  Rrill vires @ 113  All winn  gradel, medium dense, wet,					-	3	0±0=2D
Sandy Silt  Sandy Silt  Z  SSIB  Z  Water noted of Reill verls @ 113  All winn  All winn  All winn	(hat) souly sit , non-plastic, med				55 17	3	
SSIB Z  SSIB Z  Water motal of line graned growthy-  Gim) Silty SAND, fine-graned growthy-  gradel, medium dense, wet,	Sandy Silt						winter outous ATD
(Sm) Sith SAND, five-granel , poorly					SS jë	Z	tor moted o
(Sm) sith sand, fine-granel growly					.	3	Brill rols @ 1131
I 10 y x 5/3 brown [ ] ] ]	(5'm) sity SAND, five-graved y poorly gradel, medium dense, wet,			‡			Allwium
	I loyes/3 brown						

A22-34

PROJECT NO.\_

	WOO	odward-Ciyoo Consulatits was 11,00201 11.1	GHAPI	uc 106		1.	5/	MPLES	
	(FEETH	DESCRIPTION	Lithology	Plezomeler Installetion	Water	Piezoneia Defe	:73 KE	Process	REMARKS (Oriti Rele, Field less, Odor, etc.)
	14-	-(Sm) s: Hy SAND, fire-grained, poorly graded, medium duse, wet, 104x5/3 brown				1	-		
	15-	wet, loyx 3 brown</td <td></td> <td></td> <td></td> <td>  -</td> <td>00</td> <td>8</td> <td>6 PID=ND</td>				-	00	8	6 PID=ND
	16-					-			4
	17-						-		
	18-				- 1	=	-		
	19-					-	-		
	3					+		-	_
	20- 21-			2			SS		DID=ND
	л -				1000			12	
	1					-	.		
	23-	(SC OV CL) Clayer SAND or sandy				-			Allwium
0	<i>#</i>	(SC OV CL) Clayer SAND or sandy silty CLAY, five-grained, poorly gradedy medium dusc, very moist, 10/R5/4 yellowish-brown				‡			
1	75	moist, 10/ks/4 yellows state		·			25/11	68	PID=OD
6	16-					1		10	
ć	)7 <del>-</del>					+			
:	18 T	SANDSTONE: very fire grained growly graded, hard to very hard, very hard, very hard, very hard, very oxide stains, clayey in zones				+	.		Denver Fm. wenthered
2	79-	exide stains, clayy in zones				+			drilling fairly rough and difficult to 247 pt.
3	70-1- 10-1-1					-	+	16	1
3	31 <del>I</del>					13	5 16	31	PID=ND
3	2-					=			2 4
กเ	חודה	T NO. 89ME114A							SHEET 2 OF 4

Woodw	mrd-Clyde Consultants 🍱 PROJECT NAM	(L							HOLE NO
		SHAPH	IC LOS	: 5	3	4	=	4	REMARKS
(FE ET)	DESCRIPTION `	Lithology	Plezemeler Installation	Cons	Piazona Defe	y se y	ř.	2 1 0 0 2 1 0 0	
						٥	=	14-	
32+	SAME: SAND STOUT: VERY FIRE-				7		ı		Denver For
1	quairel, poorly graded, hard				‡		1		weathered
2 + .	to very hard, very moist graypests				#	_	1		
7	To Color of the Co		1		#	•	1		Donver Fr.
, ‡ ·	brown with iron oxide stains				±	:	1		
4	clayey in zones	1 . 3	İ		+	-	+	. /:	•
- I	ill come thin seams of highly	1			1			4	0-0-10
,‡ "	lustic, silly clay, loyell dovle going				1	SSI	7	33	DTO=ND
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104	) silfy clay some, highly plasticy	3:11			<u> </u>		•	0	rilling becomes
(CH	) silty clay state, highly plastic, hughly plastic,				-		•	7076	villing becomes without only stiff
(CH	) silty clay some, highly plasticy hard, moist, 1045/1 gray to				<u> </u>		14	5 r	villing becomes without and sliff of the tr.
(CH	hard a moist, loyes/1 gray to				5.5		15	5 Y	villing becomes mouther and sliff of 48 tt,
+	) silty clay state, highly plastic, hund g muist, loyes/1 gray to loye of/1 date gray  Claystone				SS		20	) >r	villing becomes without and sliff of the tr.
	) silty clay state, highly plastic, hard g muist, loyes/1 gray to loye of/1 date gray  Claystone  89mc/144				55			) >r	villing becomes mouther and sliff of 48 tt,

		GHAPH		. =		TE.	LES	REHARKS
CEPTH (FEET)	• DESCRIPTION	Lithology	Plezometer Instellation	Wo! . Conse	Pictoria Dois Type Na	P1 250.	Falt Giby	(Oritt Rate, Fluid lass, Odor, et
52	- SAME: (CH) Si Hy day SHATE, highly				- 55	B	126	Demor Fm.
2	- SAME: (CH) Si Hy clay SHATE, highly plastic, hardy moists 10/25/1 and gray to 10/24/1 dark gray							Bottom of bourned at 50.5 FEET
51-	claystone				‡ ;		·	of 50.3 FEET
52	-	·			· ‡		·	
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53					#			
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Woodward-Clyde Consultants PROJECT NAME RMA BORING LOCATION 36 Sec DRILLING AGENCY 190 Western DRILLER ayre COMPLETION DEPTH Terr CME 75 DRILL BIT NO. OF DIST. Hollow Auger 24 HRS. SIZE AND TYPE OF CASING NA WATER ELEV. LOGGED BY FHOM TYPE OF PERFORATION NA T. Terry TO FROM -FT. SIZE AND TYPE OF PACK FROM 46 FT TYPE OF SEAL Grout GRAPHIC LOG Type He Onte Person DESCRIPTION (Drill Rate, Fluid loss, Odor, etc.) Sand, silty, dry to wet, medium to fine sand, medium dense to dense, light yellowish brown to brown 10 YR 6/4 -10 YR 5/4 9 10 YR 5/3 11 7 7, 6 6 8 6 9 10 7 15 18 12 13 89MC114A or<u>.3</u>

**न्यस्ट्रिक्स** 

PROJECT NO.\_

		GHAPII	ic Log		<b>1</b> 1	SAM	PLES	PID PPM
OFFTH (TEET)	DESCRIPTION	Lithology		Content	Plezomet Date	Recor. C	# 1 1 1 E	REMARICS (Orth Rate, Fluid loss, Oder, etc)
14-		1.			‡	۱		
15-		1.5			<del> </del>	4		
10		/·. ,			‡	ı	8	
16 -		1			1 =		<i>11</i> ·	Å
		· · :			I	7		٧
11/-		. \			‡			
18		1			‡			
10		1.1			‡			
19		1.1			‡			
		1:			1			
20-	·		24.		‡		4	
2/	<u>.</u>	1	1		1		9	
		· · ·			Ĭ,	1		
22-	Clay, silty, sandy, moist, stiff, very pale brown, (CL)		.		1			
23 -	stiff, very pale brown, (CL)		40 - 10 and 14		‡			
	10 YR 7/4		No security of		‡			
24-					=			
25-					<u> </u>	4	,,	
		~./			Ŧ		4	49.7
26-		8			Ŧ	l	9	
	Sandstone, weathered, silly	1	-		1	1		
27-	Sandstone, weathered, silty sand, hard to very hard, yellowish brown (SM)	-/-	_		Ŧ			
28-	ye hours, but it is				1	ľ		
120		1.:.			Ŧ			
29-		1	-		Ŧ		·	
30					=			
30-		1:			+		35 50/4	10,7
37-		1			+	1		
					#			
32-	- QQ MC ILU M					1_		SHEET 2 OF 3
PROJE	CT NO. 89 MC114A							J., 22.1

2			IC LOG	:3	È.	5 A	E 4	REMARKS P.M
reen	DESCRIPTION	Lithology	Plezometer Installation	P Kot	P'e zon	Type	Marie Miori Elos	(Driff Role, Fluid loss, Odor, etc.
2	•	/				-		
Ŧ		1						
3±					1	-		· .
Ŧ		1			‡		1	
+		1	·		1	-	1.	
Ŧ					1			
5#					‡	$\dashv$	35	7.4
+	. 1				1		50/4	"/
;‡		//			#	-	-3.7	
Ŧ		1			#			
_ ‡					‡			
7	al stone hand either day.				Ŧ			
Ī	clay stone, hard, silty, dry, blocky, olive, (CH)	A A	.	ı	‡			•
+	blocky, olive, (CH)				+	.		
‡	5 Y 5/4			- 1	Ŧ		1 1	
+	,			- 1	+			
‡					Ŧ			
+.	•				+	4	25	0-
‡		1		1	Ŧ		35	8.2
+			-		+		47	
#					Ŧ	7		
‡					+			15.4
Ξ			1	-	+	0		12,7
#				-	+			· .
‡					Ŧ	-		
Ī					#			İ
‡					Ŧ			
‡ _	The second second			-	Ŧ			·
1	Sandstone, hard, silty, moist, yellowish brown, (sm) 545/4	1		-	‡			1
‡	Yellowish brown, (5M) 545/4				‡_			
+			.		Ŧ			
Ŧ					‡			
+					Ŧ			
Ŧ					ŧ			
+				.	Ŧ		.	
Ī					‡			
+					<b>†</b>			
‡					Ŧ			
+					土	Ш		
	NO. 89MC114A							SHEET 3 OF 3

	dward-Clyde Consultants PROJECT N	IAME	Cc	DE.	<u>D.</u>	0.	<u> </u>	HOLE NO. DO
VVOO	IG LOCATION LIME SETTLING BASINS			ELEVATIO	N AN	DAT	UM	76 July 10
DRILL	ING AGENCY LAYNE - WESTERN DHILLER R.	Albritte	n	DATE ST			6-29	
DHILL	ING EQUIPMENT CME 55 WITH 6-5/8" HSA			COMPLET			T1.0	SAMPLEN SPLIT SPEON
	ING METINOU HOLLOW STEM AUGERS WHILL BIT			NO. O	. S	UIST		COMPL // 24 HR3.
SIZE	AND TYPE OF CASING			ELEV		EINZ	14	CHECKED BY
TYPE	OF PERFORATION FROM	10	FL	LOGGED		_		
SIZE	AND TYPE OF PACK FROM	10	FT.	S. W	OP	ris	SETTE	
TYPE	of seal - Grout FROM -(	) 10 44				54	MPLES	
=-			LIC LO	2.5		\$	3 226-	REMARKS
EFTH (EET)	DESCRIPTION	Lithalogy	presion in	mater ;; €	25.35 5.53	Ž	Paris of Care	(Drill Rate, Fuld loss, Odor, etc.)
05			_		-		1	Revlian Said/5:14
0:	(Sm) silty SAND, fine-grained, poorly-graded, medium-dense, dry, 10 yr 6/8 yellowish-brown				‡			dentil
, :	poorly-graded, medium-dense,				1	-		
-	Lry, 10 yR 6/8 yellwish - 50001	·•/*/•/.			1			
	:	4- 4.			$\exists$			
2-					-			
	•	4					4	
3-	<u>,                                    </u>	1111			-	55	15 7	DE0=UD
		1.11			1		17	
4	_				-			
	//				+		•	
/			**		#	-		
3		1111		- 1 1	+		3	
[, ]			A Sept.		-	55/	15 4	PID=ND.
6-	- · · · · · · · · · · · · · · · · · · ·	4][[			#		7	
1		43 [11			‡			
7-		:11.11			+	-	1.	
' ‡	becomes moist				‡	+	+	
8 -		4141			+	-	6	PI0=ND
OF					7	55/	5 6	P20
<u>ا</u> ر		44111			Ŧ		/	•
9 🖠					Ŧ			
- 1	-11				Ŧ			
10-	yellowish-button, and becomes	11.11			+	十	1	PID=ND
Ŧ	yellowish-button, and becomes	11.			ŧ,	55/1	3,	•
11	very moist and loss e grained.					יוכי	7 73	under level noted on dvill rocks @
1	(Sm) silty SAND3				. ‡	-	-	-09:30
12-	(Sm) silty SAND, fine-grained,  (Sm) silty SAND, fine-grained,  poorly gended, loose, very  moist, 10/R5/4 yellowid-	.  -			#	-		
	moist , 10/RS/4 yallowing				‡			
13_	brown	1111			<u> </u>	.		
127		.[] []	•		‡			
,		11111			‡			
141	_							WATER ENTERS @
			- !			$\perp$		
	ECT NO. 89MC114A							SHEET OF . 3
HOJ	CCI NO.							

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PROJECT NO. 89MC114A

	ward-Clyde Consultants Will PROJECT NAI	GHAP	HIC LOG	. =		SA	MPLES	
TEET)	DESCRIPTION	Lithology	Plexameter Installetion	Conten	Piezone Data	Type Na	Raint Ball	REMARKS (Drill Role, Field lass, Odor,
14	SAME: (SM) Silty SAND, fine- grind, poorly-gradel, medium-dense, wet, 10425/4 yellowish-brown	7.11			=	-		
' Ŧ	swined poorly-gradely	[ ] - ] ]	1					
7I	a Divin-dense wet				1	-	+	1
1	median wellowish-brown	1.11	:		1		19	P=0=ND
. ‡	10 y 12 3/4 g = 11	14/11			. ]	SS	19 12	PTO-KI
0		1:1:11	4		4	:	10	
‡		1111		1	‡			Ī
7.4		111			+	- 1		
. ‡	•	11.[][			+			
, ‡	•	1971			#			
8 <del>+</del>	•	1711			- ‡		1	
#	•	: 3-14	\\ \ \ \ \ \ \ \ \ \ \ \ \ \ \ \ \ \ \		<u> </u>		1 1	
94		1.1.1.1	1 1		+	-	. 4,7	
` ‡		1-1111	[		1			
‡	<i>i</i>	1.1.1	l·		土			
2 <u> </u>		1411	,		+		1	. •
#		41.11.			1	55/	14	P=D=ND
1+	· · · · · · · · · · · · · · · · · · ·				1		1.1	•
‡ .					‡	_	19	
#	· · · · · · · · · · · · · · · · · · ·			.	+	.		
H.		1 1 1 1 1			#			
Ŧ.	a de la seconda		Newson		#		1 1	
) <del> [</del>		1-1-1-1	1		7			, t
#	sandy				Ŧ		1 1	
<u> </u>		1111					.	
1(0	plustic, weathered, 104 to meliun			-	Ŧ	-  -		Denver Fm.
‡`	plustic, newhered 10 yrs 13		1		Ŧ			: .
+	brown Claystone		,		Ŧ			1 <b>55</b>
$\frac{1}{2}$					Ŧ	SH	4	P=0=17 ppm
I .					73	יוןכי		
100	CL FCH) silly clay SHALE low medium!				1	$\perp$	11	Denver Fm
+ `	highly plustic, weathered, with		1		Ŧ			
Ŧ	Coase Line avained start of				7			
Ŧ	10 yas/1 gruy claystone				Ŧ			
±				1	+			
=					Ŧ			F.
+(5	slightly silfy SANDSTONE, very fine granded, very fine granded, very dense, 10 yr 5/4 yellowish-brown		1		Ŧ		1	Senver Fn
+	graned, poorty grada, very		l	1	Ŧ			CORE RUN#1
<b>.</b> ‡	dense joya 5/4 yollowin - 965WA		1		to	CIB		PIO=ND
‡		1			+		- 1	
‡ w	ith hardy calcaverus concretions 30.5 feet	18.50			-	++	5	SAMPLER MET
7 at	- 30.5 feet				‡			CEGNIAL AT 36.5 FT
Ξ.			[		55		770	
+	· · · ·		- 1		7			
-1-					1.			

. A22-42

	dward-Ciyde Consultatis W 1 100 Ect 100 mm	GHAPH	ic Los	.=	ä	54	in.	LES	
OEPTH (FEET)	DESCRIPTION	Lithology	Plezemeter Installation	Confec	Piszons Defe	Type Ma	Asco.	Parte Bait Giosa	
32-	SAME: (SP) slightly sity SANOSTONE,					-			Denver Fr
33-	very fine to five grainel, poorly graded, very dense, 10 yr 5/4 yellowish-brown								
24	10 yr 5/4 yellow 34-5rown					-			Attempt to cove
77:		·							at 34.0 feet met with runger refusal.
35-		·							·
36-					#	-			
27					-	_		``.	
37-					‡				
38	<u>-</u> :					•			•
39-	<u>:</u>	17.7			#	$\dashv$	+		CORE RUN#2
40-					-	C			
1 ‡			N. was		1	0			
41=			No. of the state of		3	2	8		:
42	-				17	2			
43					+				
1	(CH) silly day SHAVE, highly plastic,				Ţ				Donver Fm
44=	harda loye 4/1 dark gray				Ŧ		T		Bottom of boving at 44,0 feet
45	Claystone				+			.	
1,4					1	.			
46-					‡				
47					#				
48					#				
49-					‡				
1 ‡					‡				
50-1-	T NO. 89MC114A				1				SHEET 3 OF 3
1100000	1 NO								

HOLE NO. LSB-24 COE D.O. 1 Woodward-Clyde Consultants PROJECT NAME WOHING LOCATION LIME SETTLING DATE STARTED 6-25-90 6-26-90 DHILLEH Kevin Cruss DHILLING AGENCY LAYNE - WESTERN COMPLETION DEPTH 29,5 SAMPLER3 400 Split Spoon DRILLING EQUIPMENT CIME 55 with 6-5/8" OD HSA DRILL DIT DHILLING METIND Hollow Stom augers FIRST SIZE AND TYPE OF CASING CHECKED BY LOGGED UY 10 FHOM TYPE OF PERFORATION 10 S. MORRISSETTE FROM 1029.5FT TYPE OF SEAL GROUT FROM 0 GRAPHIC LOG Recordi. Canten Person Lithology DESCRIPTION (Drill Rate, Fluid toss, Odor, etc.) July SAND of ne-grained , poorly gradel, medium dense , dry , loye 6/4 light yellowith - 51000d dedian SAND ? SILT 2 PID=ND PID=ND 12 ‡ss|/\$ becomes moist 10 DID=ND 155 11 9 becomes love-5/3-yellowit-Alluviula - (SM) silty SAND, fine-grained,
poorly graded, medium lause,
moist to very moist, 10 yes/3
- yellowish-brown .55 PID = ND

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A22-44

SHEET\_\_\_OF\_\_\_\_\_

89mc114A

PROJECT NO.

		GHAPH	C LOG		È	_	E	LES	REMARKS
E	DESCRIPTION	Lithology	Plexometer	Wole.	E E	N a	7	THE STATE	(Dritt Role, Fluid less, Oder, etc.
0.E	(sm)	1111		_	-	5	٤	E K.	
14-	- SAME: 3: Hy SAND, fine-grained,					-	П	•	Allwium
	poorly graded, medium	:11:11:			]		П		
15-	CANTILLOS  CANTILLOS		·•						
1	yellowish-brown	CONTINUE CONTINUE STATE OF THE PROPERTY OF THE		DIN=ND					
1/-	O .	1.1:1				ري.	11		4
			Í	1	-	:		1.0	
1					. ~				
17:	-	11111	. ]	· 1	-	-		.	
. 7	SAME SITY SAND Fire grand Property of the state of the st								
107	SAME SIME SIME SAND fire arminal seconds of the seconds of the seconds of the seconds of the seconds of the seconds of the seconds of the seconds of the seconds of the seconds of the second of the s								
107	SAME 31 Hy SAND, fine - princed the second of the second o		·						
1	SET DESCRIPTION  (SIN)								
19	SET OF SCHOOL (SIN)  THE SAME: 3:149 SAND, five a granted plantation of the second plantation of								
DESCRIPTION  SET OF SAME 3: HE SAND, fine a principal property grades, making international property grades,									
4	SET OF SCRIPTION  (SIM)								
100	SAME: SIHY SAAD, Fine - grands between 2 1 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2			•					
#	SAME SITY SAND Fine - something to the mental of the menta		PIO=2.0ppm						
217	SAME SITY SAND FIRE SITY CAPY highly  Plastic, have seen point of plastic, have seen point of plastic, have seen point of plastic, have seen point of plastic, have seen point of plastic, have seen point of plastic, have seen point of plastic, have seen point of plastic, have seen point of plastic, have seen point of plastic, have seen point of plastic have seen point of								
Ŧ	Commence of the control of the contr								
22 +	Colling the state of the state								
1	SAME SITY SAND, fire a principle of the stat								
. I	SAME: SIME SAND, fine a private of the desire of the stat			•					
23-	SAME SITUS SAND fire agrained the mental property grades prediction and provided the mental provided the second state of the s			<i>;</i>					
7	SAME: 5:14y SAND fine arrival property grades, made any grades, made any grades and the second grades are second grades and the second grades and the second grades are second grades and the second grades are second grades and the second grades are second grades and the second grades are second grades and the second grades are second grades and the second grades are second grades and the second grades are second grades and the second grades are second grades and the second grades are second grades and the second grades are second grades and the second grades are second grades and the second grades are second grades and the second grades are second grades and the second grades are second grades are second grades are second grades and the second grades are second grades are second gra								
24	SAME: SIME SOLD Fire a primate to the south that the second of the south that the								
-	SAME SITY SAND Fire - primed by the tenther of the		, , , , , , , , , , , , , , , , , , ,						
#	DESCRIPTION  (Str.)  SAME: SIME SAND, fine - princed intention of the strength								
25-	Control (Sp.)  (								
+	CAMPE SAME STAND Fire agriculture to the state of the sta			P=0=3.2ppm					
‡	Commence (Shi)  SAME SIMP SAPA Fire grand Remark Size Size Size Size Size Size Size Size			PIO in HSA=168pm					
26-	SET DESCRIPTION  (SIM)			Denuer Fm					
#	SAME: SIME SAND, fine of principle interesting to the same of the			core run#1					
27±	SECURIOR OF SAME SAME SAME SAME SAME SAME SAME SAME								
1	SAME: 3:149 SAAD, five graded, mariners  SAME: 3:149 SAAD, five graded, mariners  Lesses, Det, 10425/3  yellowish -6 vows  10  20  21  22  23  26  DEATHERED SHARE: 5:149 CEAY, highland plastic, hard, year, which was a part of the control of the c								
-	SAME: SIME SAPD fire grand standard sta								
28 🛨	DESCRIPTION  (SM)  SAME: SIME SIME Fire - primate interest in inte								
Ŧ			.		‡		1		
A T	CENTRE OF SHAPE SHAPE (A) CAYS highly with two control of the cont								
T	CHAPTER SHAPE SHAPE (ALL) SHOPE SHAPE (ALL) SHAPE (ALL								
Ŧ	DESCRIPTION  (SM)  SAME: SIMUSAND, fine amount of the interesting of the state of t						Bottom of build		
30 <del>-</del> -			- 1		. ‡				\$ 29.5
Ŧ		j			‡				
3/ I			1	1	+				
T					‡		Į		1
	••	- 1	Į		Ţ				I
32-1-					上		L		
	- 40 89mc114A								SHEET ZOFZ

HOLE NO. LSB-25 COE D.O. 1 Woodward-Clyde Consultants PROJECT NAME WOHING LOCATION LIME SETTLING BASINS 7-6-90 UNILLER R. Albritton DHILLING AGENCY LAYNE-WESTERN SAMPLEIS" OD Split Spor COMPLETION DEPTH 43.5 UNILLING EQUIPMENT CAN F 750 W/6-78" OD HSA UIST. 0 HOLLOW STEM AUGERS FIRST 7.0 24 HH3. SIZE AND TYPE OF CASING CHECKED BY LOGGED UY FHOM 10 SIZE AND TYPE OF PACK FROM -S. MORRISSETTE 1043.5FT TYPE OF SEAL FROM GROWT GHAPHIC Recording Residency DEPTH GEET) REMARKS Onten DESCRIPTION Lithology (Drill Rais, Fluid loss, Odor, etc.) Installation (3m) 31 Hy SAND firequainely poorly grades, medium-dense, dry to Fill mist, loyes/3 brown, upper 0.5 reet gravelly Silty CLAY, low to medium fastic, medium stiff, moist, 10427/1 F:11/sludge (?) light gray PIO=ND Fill 5 122 Marin Alleganic PIO=ND 6 water enters (SM) 5: Hy SAND, very fine-grainely, poorly-graded, very losse, it, 10423/6 dark gellowish-brown Allmium PIO=ND <del>1</del>55 becomes loyes/fyellowish-brown and medium-dense PIO=ND 11 3 ROJECT NO. 89MC114A OF 3 SHEET /

Noodward-Clyde Consu		NAME		D.O. 1	HOLE NO.	
UDHING LOCATION LIME SET			i	H AHD DATUM		
HILLING AGENCY LAYNE-WE		. PARKER	DATE STA	BUED 6-3C	7-/6-26-9	0/6-2
HILLING EQUIPMENT CAME 22 M	11L 6-5/8" HSA	•	COMPLETE	ON DETTII 34	SAMPLEH SPIT+ 5/	oon
HILLING METINU HOLLOW STEP	AUGERS DHILL BIT		HO, OF	s 10151. 8	UNDIST.	
IZE AND TYPE OF CASING			WATER ELEV.	FIRST /D	COMPL 7.5  24	IR3.
THE OF PERFORATION	FROM -	10 F1.	LUGGED (		CHECKED BY	
ZE AND TYPE OF PACK	FHOU	10 FT.	٠			
TPE OF SEAL	FHOM	O 10 24FT	5. m	orrissette		
- 67	rout -	GHAPING LO	c	L SAMPLES	<del> </del>	
DESCR					REMARKS	
DESCR	IPTION	Lithology Piero	meler 3 €	2 2 E 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2	REMARKS (Orlil Rate, Full loss,	Odor, etc.)
		1		15 6 6 6 6	1	
( ±(SIM) silty SAND.	, fine-grained groot/ - dense, clvy tomoist, L brown	yl XI IXI	- 1 4	# 11	Fill	•
I graded, mediun	- dense, dry fomulst.			11/		
+ INVES/4 Yellowis	L brown	KIIN	4.4	+ 11		
Т 1				± 11	1. 2	
#Fill		UIN	71.1	± 11	<b>V</b>	
+'''				Ŧ 11		
‡ ·				<del></del>	†	
, ‡		KIII	<b>-</b> 4<1	+ 15	100	
<u> </u>		NA		55 12 12		
, <u>+</u>			$A \perp 1$	# 1 1/2		
<del>-</del>	·	N/ W			1	
-			74. 1	\±		1
+ (CE) SIHA CLAY.	low to medium un to Stiff, loyp8/1			Ŧ II	Sludge PIO=ND	: 1
The state of the s	un to Stiff love8/1			+ 16	7	İ
المناس المناس المناس	W- 10 2111 9 13/1. 77 1			55944	1	
+ C. II MOIST	1	7	-1-1	# 1 4	PIO-ND	
I Fill	,			# 11		1
+				1	ع بر د	0545
1/ 50 10 6	. 0 1			+ 11	weder as of	- 1
+(SM) SI Ity SAND, +	ne-grainely poorly- dense, very lark yellowish-	[ <del>1]</del> [[1]	1 1	‡	Allivium	- 1
+ graled, medlum	- dense y very			14		- 1
+ moist, 10 y 2 4/4	lark yellowish -		11	'./	P=0=4.01	pm [
I brown	The second second	1-1-1-1-1		\$55 14 T	PIO	'
‡				I     '		- 1
<b>+</b>				1-11-		
<u> </u>	man a market of the state of th			± 11		
<u> </u>		1.1.7.1.1		+ 11	Water ant	eus
Ŧ. ,				55 17 3 16	ATD (10 PT)	
becomes wet	4	<b>                                   </b>		55 17 4		
<u>+</u>		1-1-1-1		127/11/6	DIO = ND	1
#	' / /	[1-14]		#		- 1
<u>+</u>	$\times$ //	14111				
- -	$\mathcal{N} / \mathcal{N}$	4-1-11			. •	- 1
Ŧ	184. A	F1.3-171		Ŧ     ·		
Ŧ	**	74141		Ŧ		1
- <u> </u> -	يعمون	4-1-1-1		T		1
<b>‡</b>	P. V. M. R. vak	1 H11		# 11	•	
<u>+</u>	<i>[1]</i>	111		L		- 1
			1			1
JECT NO. 89MC11	4A 1				SHEET / C	)F 3
JECT NO O THE T	111				mart / (	n·

COFE RUNH/

: becomes 10 ya s/3 brown and siltier at - 31.5 feet to 32.5 feet

OJECT NO. 89MC114A

HEET)	DESCRIPTION	GHAPH	C LOG Plezometer Installation	Weite	Fatorater Deta		TE TE	REMARKS (Ortil Rate, Fluid Sess, Oder, etc.)
32-	- S'AME: (CH) slightly sauly silty capy, highly plastic, melium hard			-		•		Denver Fm. are rm#1
33	highly plastic, medium havel a very moist, 10 yr 5/3 brown with some iron oxide strining				+	cck		
34	becomes 10426/2 brownish - gray from 32.5 to 34.0 feet				+	+		Bottom of boving at 34.0 feet
35	Claystone				-			2 34.01
31					#		4	
37					‡		~ .	>
38	-				1			
39					‡			
40=					‡,			,
1		many a many a many and a second secon	The state of the s		1			
#					‡			
-					‡			
· ‡				.	-			
‡				_	‡			
+					‡ + +			
7								
1					-			
<del> </del>	The state of the s				-			
				-	-			
NOJECT I	NO. 89MC114A		_			-1	!	SHEET 3 OF 3

Woodward-Clyde Consultants PROJECT NAME RMA COE HOLE NO. <u>LSB-0</u>27 DORING LOCATION 36 DRILLER R. McKay DRILLING AGENCY arne Western COMPLETION DEPTIL DRILLING EQUIPMENT UNDIST. NO. OF Hollow Auger 24 HRS. COUPL WATER CHECKED DI LOGGED UY FHOM T. Terry SIZE AND TYPE OF PACK FROM . 10 35 FROM TYPE OF SEAL · Grout GHAPHIC LOG Water DEPTH GEET) DESCRIPTION F (Drill Rate, Fluid loss, Oder, etc.) Sand, medium to fine sand, trace silt, trace day, loose to medium dense, dry to wet, yellowish brown to brown, (SP) 10 YR 5/6, 10 YR 5/3 SM 455 6 8 3 9 10 3 12: 13

A22-52

PROJECT NO. 89MC114A

SHEET / OF .3

•	MA.			RM
Voodward-Clyde Consultants		PROJECT	NAME	

	rd-Clyde Consultants PROJECT NAM	GHAPHI	c LOG	:=	= g	= 4-8-	PIREMARKS
	DESCRIPTION	Lithology	Piezometer Installetion	Conti	Piezor Do Type h	Pacor.	(Dritt Rate, Fluid tess, Odor, atc
+		1			+		
Ī		×			‡_		
+-	1:11/2 andie				T	15	22.6
Ŧ	Clay, slightly salay)	Y - /		·	<u> </u>	15	. 22.0
+	Clay, slightly sandy, medium stiff, wet, yellowish brown (CL)				1 =	1 9	
‡ •	10YR 5/4	1/			1		
+	10 11 377	Y/	1.		‡		
‡			1		1 ‡		
+					‡	$\{\}$	
, ∄					1 ‡		1
<b>*</b>			1		Ιŧ		
2	•	1/	1		1 =	1/7	32,4
<u></u>					‡	11/11	1 3211
,‡	Weathered claystone, blocky fractured, moist, very stit	11			II	15	
<b>†</b>	fractured, moist, very stit	7	1		1 1	.     _	/
2十.	to hard, light brownish gray,				lŧ		
Ξ.	grayish brown, dark grayish		-		1 =		
生	brown (CH)				<del> </del>		
, ‡	104R6/2, 104R5/2				17		
T	- 46 y		1		‡		
5 ‡	10 YR 4/2				1 ‡	1/1/	10
, ‡	- the same of the	/			I	24	155.8
<u> </u>			4		十五	30	
Í	and the second of the second o				1 =		
7#			1 1		17	=	
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3÷		/			1 1/	9	
‡					1 1	-	
9 1					‡		
T T	· Sylv	-6	1		1.+	-	
T.	Claystone, moist, hard, very dark grayish brown, grayish brown (CH) 104R 3/2, 2,545/2				1 1	c	
小王	very dark grayish brown,				1 ‡	0	
Ī	grayish brown (CH)				I	R	·
ŗ,							SHEET 2 OF
	NO. 89MC114A						SHEETO

HOLE NO. <u>LSB-0</u>27 Woodward-Clyde Consultants PROJECT NAME RMA COE REMARKS (Ortil Rete, Fluid toss, Odor, etc.) DESCRIPTION 32-33. 34 35

98888855

89MC114 A

PROJECT NO. .

SHEET 3 OF 3

codward-Clyde Consultants PROJE								NO	
DRING LOCATION Sec 36			ELEVAT	ION AN	D DATE	JM		e, e	
RULING AGENCY Layne Western DAILL	LERA. McKa	V	DATE S	TARTED	7.	-2-9	0.		• 1
RILLING EQUIPMENT ( &A E 75	13777		COMPLE			36	SAMPLER 7	Terr	y
THELING METINO Hollon/ Auger DAIL	L BIT		NO.	OF ES	DIST.		UNDIST.	120	
ZE AND TYPE OF CASING NA	•		WATE		FIRST	9.0	COMPL	24 IIRS	• .
PE OF PERFORATION N/A FROM	10	FT.	LOGGED	**			CHECKED B	Y	
ZE AND TYPE OF PACK ALA	i . TO	FT.	7. 7	Teri	^ <i>V</i>				٠.
1777	0 103/	r FT	,,,,		/				. 1
PE OF SEAL Grout FROM		)	3	16	SAV	PLES	PIN	PP	M
DESCRIPTION	Lithology	Pleton	mler 5	Plezoner Dete	Type Ha	Penetra Resist (Bbes/	(Orill Rale, F	MARKS. Juli loss, Od	or, etc
Sand, silty, clayey, dry, medium dense, brown, (SP) 10YR4/3 (SM)	Jid. Jak.					6 8 8	5,	0	
Sand, Slightly silty, trace clay, dry, loose, wet, fine sand, yellowish brokes, 104R5/4, 104R6/4	ce				-	м w w		4 A	. •
(SM)					-	<i>5</i> 9			
				+++++++++++++++++++++++++++++++++++++++		3 7 1	0,	8	
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DESCRIPTION	Lithology	Piezameter juetaliation	Wote	Pietom	Type K	1 2 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0	Drill Rate, Fluid loss, Odor, etc.
1				+			
				Ŧ		58	49,7
Stay, sandy, very stiff, light yellowish brown, moist to	/	·		#		11 -	
7 = very moist, 104R6/4 (CL)				1			
9 <del>‡</del>		·		#			
‡				Ī			
Weathered claystone, very				#			
Weathered claystone, very stiff, moist, light brownish gray, blocky, fractured,				ŧ	-	6	
1 10 YR 6/2				#		13 18	
= 11072				‡	,		
				‡			
	1			Ŧ			
4				#		·	
‡				1	-	15	
				‡	-11	37	32,6
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	No.			1	+  :	20	
<u>T</u>				+	$\Pi$		

DESCRIPTION			1				
	Libology	Plezometer Inetalistion	Content	Typ. H	Paco.	₩ (	Dritt Role, Fluid less, Odor,
mill watered bustons	1			+=		-	
ard, moist, dark grayish rown, iron oxide staining,	A STATE OF THE PARTY OF THE PAR		-1	‡	Ш		
rd, moist, dark grayish		1 1		Ŧ	Ш		•
vn, Iron oxide staining,	and the second	4		Ŧ			
R4/2	The state of the s	1. 1	.	ΞC	П		
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DHILLING METIKOD HOllow Auger  SIZE AND TYPE OF CASING NA  TYPE OF PERFORATION  SIZE AND TYPE OF PACK NA  FROM TO FL LOGGED BY  SIZE AND TYPE OF PACK NA  FROM TO FT. TO FT.  TYPE OF SEAL  GRAPHIC LOG  GRAPHIC LOG  GRAPHIC LOG  DESCRIPTION  LIMBORY PROMORDER  SIZE AND TYPE OF PACK  TO FT.  TO FT.  CHICKED BY  CHICKED BY  CHICKED BY  LIMBORY PROMORDER  DESCRIPTION	erry
DRILLING EQUIPMENT CME 75  DRILLING METIKOD Hollow Auger  DRILL BIT  NO. OF DIST.  SAMPLES  SAMPLES  DRILL BIT  NO. OF DIST.  SAMPLES  SAMPLES  DESCRIPTION  DESCRIPTION  COMPLETION OFFIL 25  AND OF DIST.  UMOIST.  SAMPLES  PLOY  CHECKED BY  CHECKED BY  CHECKED BY  CHECKED BY  DESCRIPTION  DESCRIPTION  COMPLETION OFFIL 25  AND OFFIL 25  COMPLETION OFFIL 25  AND OFFIL 25  COMPLETION OFFIL 25  AND OFFIL 25  COMPLETION OFFIL 25  AND OFFIL 25  COMPLETION OFFIL 25  AND OFFIL 25  COMPLETION OFFIL 25  AND OFFIL 25  COMPLETION OFFIL 25	. /
DRILLING METIKOD Hollow Auger Drill BIT NO. OF SAMPLES DIST. UNDIST.  SIZE AND TYPE OF CASING NA WATER FIRST COMPL.   Z  TYPE OF PERFORATION NA FROM TO FI. LOGGED BY  SIZE AND TYPE OF PACK NA FROM TO FT. TO FT.  TYPE OF SEAL C-rout FROM 0 10 25 FT  GHAPHIC LOG SAMPLES PIREMARI	. /
TYPE OF PERFORATION  NA  FROM  FROM  TO  FI.  LOGGED BY  CHECKED BY  TYPE OF SEAL  COMPL  FROM  FROM  TO  FI.  GRAPHIC LOG  GRAPHIC LOG  GRAPHIC LOG  GRAPHIC LOG  GRAPHIC LOG  FROM  LIBROROW PROMOBING  FROM	14 IIRS.
TYPE OF PERFORATION NA FROM TO FT. LOGGED BY  SIZE AND TYPE OF PACK NA FROM TO FT. TO FT.  THE OF SEAL GOOD TO TO TO TO TO TO TO TO TO TO TO TO TO	
THE AND TYPE OF PACK NA FROM TO FT. T TONY  THE OF SEAL GOOD TO SET TONY  THE OF SEAL GOOD TO SET TONY  THE OF SEAL GOOD TO SET TONY  THE OF SEAL GOOD TO SET TONY  THE OF SEAL GOOD TO SET TONY  THE OF SEAL GOOD TO SET TONY  THE OF SEAL GOOD TO SET TONY  THE OF SEAL GOOD TO SET TONY  THE OF SEAL GOOD TO SET TONY  THE OF SEAL GOOD TO SET TONY  THE OF SEAL GOOD TO SET TONY  THE OF SEAL GOOD TO SET TONY  THE OF SEAL GOOD TO SEAL GOOD	• ••
THE OF SEAL GROWTH FROM O 10 25 FT SAMPLES DID PREMARI	
DESCRIPTION LIBRORY PROPRIET SEE STATE	
DESCRIPTION Lithology Plazometer 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2	OM.
	ics.
mstelletion ≥0 =	iss, Odor, etc.)
= Class cary sundy very majet -/:	
Clay, very sandy, very moist,  fine sand, dark yellowish brown  stiff to very stiff (CL)	
+ fine sund, dark yellowish brown + +	
± stiff to very stiff (CL) ()	
z+ 10YR4/4 /	
`# '`'\'''	
,‡	
3 +	
+ V- 1   1 + 1   1	
	i
Sand, silty, wet, mostly fine sand, medium dense to	
+ sand medium don'se to	
I dence dark arrayish hopen	1
7 20130) 4411 914 11 11 11 11 11 11 11 11 11 11 11 11 1	
+ prown (5P, 5N)	
10 YR 4/2, 10 YR 6/4, 10 YR 5/3 11 10	1
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JECT NO. 89MC114A SHEET	OF_2

		GRAPH	ic LOG		5 S.	MPLES	
(FEET)	DESCRIPTION	Lithology	Plezometer Installetion	Conten	Pistomet Date Type Ma.	Prece, fi	REMARKS (Dritt Role, Fluid less, Odor, etc)
17 15 17 17 17	Weathered Claystone, silty, sandy, stiff, dry to moist, pale brown (CH) 104R 6/3				+	6 9 14	91.4
18	Claystone, siltstone, little sand, moist, hard, pale brown (CH)				***	16	
21 - 22 - 23 -	10 YR 4/6				***	28 36	72,4
24-					+++++++++++++++++++++++++++++++++++++++		
+++++++++++++++++++++++++++++++++++++++					111111111111		
					* + + + + + + + + + + + + + + + + + + +		
PROJECT	NO. 89MC114A	1			T	11	SHEET 2 OF 2

Woodward-Clyde Consultants 😂 F	PROJECT N	JAME		0	20	Ξ.	<u>D</u> .	. 7	). <u>1</u>	HOLE NO. UB
BORING LOCATION LIME SETTING E	345125			ELE	VATI	OH AN	D DA	TUI	4	1 's, 6
DAILLING AGENCY CAYNE-WESTERN	DHILLEH M.	WALK	L			AHTEU		-		-90
DHILLING EQUIPMENT CHIE 750 W/6-5/8"						Юн	_	_	-	SAMPLEY HOO SAIT YOUR
DHILLING METHOD Hollow Steen augus	DHILL BIT			SA	MPL	ES	0151		5	UNDIST.
SIZE AND TYPE OF CASING					CLEV	•	FIRS	51 /	7.0	COMPL // SEINS. AD
TYPE OF PERFORATION	FROM	10	FL	LOG		•	_			CHECKED BY
SIZE AND TYPE OF PACK	FIIOM	10	FT.	5.	n	wh	Ris	32	गार	
TYPE OF SEAL . ( ROLLT	FROM O	1025								
E DESCRIPTION		Lithology	Plezor Insidi	meter	Water	25.35 F 25.48	Type Ha.	1.4	S In Case	REMARKS. (Drill Rais, Fluid loss, Odor, etc.)
05		7.	_	-			-	۲	2	
(Se) change silty SAND of Five poorly quality median de moisty loyes/3 brom to 104.	egrandy ruse, e.6/3					1.1.1.1.1				
(SM)		:/2	1		i					
3 +				4			<u>s</u> s	18	5	PIO=ND
<b>,</b> ‡		1/1				#			6	
4 <del> </del>										
5 = becomes 10 yr 5/6 yellowish.	bearn	1.7			1	7		+	5	
6			-				<u>ss</u>	le le	67	PID=ND
						+		†	-	water aders ATD
						‡				NOTE: 7.5 FOOT SAMPLE WAS MADURETEN
						+				Scipped By Driver. WILL NOT ATTOMPT TO RESAUPLE AS TO BEG CLADES INSTRUCTIONS.
7‡				1.		1	•			anous we
0 #						Ĭ	+	+	6	
1 = becomes 104x5/4 yellowith-Lor	wa and		•			15	35/	3	11	DIO=6ppm
						+		T		
3-						1				
<i>f</i> =						ŧ				Prilling Secones

89 mc114A

PROJECT NO.\_

SHEET 1 OF 2

Woo	dward-Clyde Consultants PROJECT NAM						DI FC	
		GHAPH	c Log	- 5	÷	344	4	REMARKS
OCFTH (FECT)	• DCSCRIPTION	Lithology	Plezomeler Installation	Suc.	Pietori Petor	12	7 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2	
J.	•			_	<u> </u>		240	
114						1		Donver Fr
17.	(CH) Souly sitty asyg medium to highly				#	ı		weathered
1:	dutic medium hard very			1	+			·.
112-	- List 10 vr3/2 vern dark	*******			F		8	
1 3	brown to loveled light		1		Is	s le	12	PIO=7 ppm
1,, 3	plustic, medium hard, very dork nisist to wet , 10 yr3/2 very dork grouph - brown to loyelf t light	-				ľ	26	
16-	- cyllowish brown, very blocky and	****			-			
	crumbly, with some seems of				1			
17-	very fine grained SANDSTONE		• -	.				
1''		-			1			<i>\</i> .
1 .1					Ŧ	1		
18-	•		1	**	+			
1 1		3			<b>†</b>			
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19-	_		. 1	- 1	-	T	30	0-0-CG:0m
1 1			· ]	- 1	‡.~	1	24	PID=59ppm
1 1	: //		.		12	1		Demor Fr.
20-	( 1) -11 of ware hinkly plustic.				F	1	24	
1 7	medium hard to hard, very mist, 10 yrb/3 pole brown to		77		-	+		ave run #1
21-	medium hack to have y very		" ,"			,		
10/7	mist, 10 yeb/3 pale brown to			- 1	10			
1 7	10 yr 6/4 light yellowish -brown			- 1	+0			0
22								
1 ‡	Claystone		1		10	D		.]
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27-	The second secon	-			-1-	11		l
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	29 MC114A							SHEET 2 OF 2

PROJECT NO.

SOUTH ASSET Layne Western OPALER R. McKay CONTRICTION DETTING OF CONTROL OF THE TOP TO THE TOP	BORING LOCATION	Sec. 36	larus sa s	41 15		DATE ST			- /	7.0		
BRILLING CONTINUATION AGE TO STATE COMMENT OF THE CONTINUATION AND THE C	DRILLING AGENCY	Layne Western	DRILLER	McKay		DATE FIN	ISHED		-3-7	SAMPLER -	- 70 0-2	<u>.</u>
Salte AND TYPE OF PEAK NA  DESCRIPTION  DESC	•	-1112				_ <i>i</i>			70	LUNDIST.	, (e) 1)	_
SIZE MIN TYPE OF PASKATON NA PROW TO PE LOGGED BY  TITTE OF PERSONATION NA PROW TO PE T. T. TELLY  DESCRIPTION  DESCRIPTIO			DRILL BIT			SAMPL	ES	<u>i                                      </u>		COMPL	24 HRS.	_
SITE OF PERCONATION  DESCRIPTIO		/1//	455014					•		CHECKED BY	<u>'</u>	_
THE OF SEAL Growt FROM O 10 30 FT CONTINUE TO SEAL GROWTH THE OF SEAL							_	Y			•	•
DESCRIPTION  DESCR	SIZE AND TYPE OF	PACK NA				1. 1		/			, .	
DESCRIPTION  LITHOUTH TETERONIC SET OF THE PARTY OF THE P	TYPE OF SEAL	Grout.	PHOM C	" 30			,			010	DRA	
Clay, sandy, sitty, very moist,  1 soft, yellowish brown,  10YR5/4 Let) (5M)  Sitty Sand with Clay  Sitty Sand with Clay  Clay, sandy, wet, medium dense, yellowish brown, (10YR5/4) (5M)  Clay, sandy, wet to very moist, stiff dark brown, to dark yellowish brown,  10YR4/4, 10YR4/3 (CL)  11  16  11  16  11  11  16	111111111111111111111111111111111111111				Pleton		Plex Smere Date	ž.	Series (Series )	(Drill Rate, F)	MARKS, uld loss, Odo	r, e
	Soft 10YA 2 Sil- 3 Sand Med brown Clay 10Y 10Y	yellowish brown 5/4 Let (SM)  ty Sand with Constitution dense, yellow (Sm)  (sin, (104R5/4) (Sm)  (sandy, wet to dark be dark yellowish be dark yellowish be deared.	vet, ish M) very rown,						4 588 681 60	38	3.1	
	3								·			

CONTROL COM

(TEET)	DESCRIPTION	GRAPH	Plazometer Installation	Woter	Plazoneter Dode Type Ma.	Merces The second	PIREMARKEM (Dritt Rate, Fluid loce, Oder, etc)
14 15	Weathered Claystone, dry little to trace sand, very stiff, dark brown to					10	
16	pale olive (CH) 10483/3,546/3				+++++++++++++++++++++++++++++++++++++++	17   24	
18					# # # # # # # # # # # # # # # # # # # #		
20	• •				+	9	30,4
21 = 22 = 22 = 2					+	15	
23 + 24 +					**		
25	Claystone, dry to moist, trace sand, grayish brown, very stiff, (CH) 2,545/Z				+++	9	91,4
26					11.	21	97.4
28 <del>+</del> 29+					11111111111		
30		A Company of the Comp					
PROJEC	T NO. 89MC114A				+		SHEET 20F 2

Consultants OF F	PROJECT 1	NAME	a	E	<i>D.</i>	٥.:	1	HOLE NO. LSE
ORING LOCATION LIME SETTLING	BASINS			ELEVA	TION A	NO DA		1 i., a
RILLING AGENCY LAYNE-WESTERN	DRILLEIM .	WALKE	R	DATE F	MISHE	D	-	-90 / 7-8-90
HILLING EQUIPMENT ONE 750 W/ 6-5/8" H	ISA			COMPL	ETION	_	30 F	
HILLING METHOUS HOW Ston angus	DHILL UIT			SAMP		0151		UNDIST.
ZE AND TYPE OF CASING -				WA?	EH EV.	FIRS	3.5	
PE OF PERFORATION	FROM -	10	FT.	LOGGE				CHECKED BY
ZE AND TYPE OF PACK	FROM	10	FT.	5.1	WR	kis.	SETTE	=
PE OF SEAL GROUT	FROM O	10 30.0	FT					
DESCRIPTION .		Lithalogy	Piezor Instali	meter o	Piezonete Cate	Type Na	Penetra Sandm	REMARKS.  Colli Rale, Fluid loss, Odor, et
(Sm) si Hy SAND, fine - yr porty gradel, med. d moist, 10/R 5/3 brown	ninely leuseg							Fill facolion soul
becomes very loose			1		1	.SS	Y 1	PID=ND water entars ATD
+ + + + + + + + + + + + + + + +							613	bID=ND
Secones siltier in gones  (per) stightly sandy siers non- medium dense, very mois	-plastic,					55 /2	469	PID=ND Allwiun
(SM) Silty Sand			•			25/4	5 8 10	PIO=ND
(SC to CL) clay of SAND to sithy ccay, med. dense to St grained, pourly graded, very i	sandy /				+ + + + + + + + + + + + + + + + + + + +			Allwium reworked Shale

89 mc/14A

PROJECT NO.\_

SHEET 20F 2

Woo	dward-Clyde Consultants ( PROJECT NAM	E	GE		0.0	, -	7	_110LE NO. LSB-3
OCPTH (FEET)	DESCRIPTION	Lithology	C LOG Plezomeler Jestoliation	Woter Content	Pietomefer Dete	SAI d d	TES THE STATE OF T	REMARKS (Drill Role, Fluid less, Odor, etc)
14-	SAME: (SC to CC) clayery SANO to Sundy sitty CLAY, med. dense to	7-1			+		<u> </u>	Allwium reworked shale
15-	gudel, very mist, 10 yr 8/2				1	5	5	PID=348Pm
16-	white				11111	_	10	
17-		.5/2			1			
18-					1			
19 -	CAMPATONE: (SP) fine-quained a poorly				1			Donver For
20-	SANOSTONE: (SP) fine-grainedy poorly graded g very hard, very moist, 104442 dark grayish-bran				1.45	5	33	wenthered PID=ND drilling becomes harder at 19,54.
21-					#	┤ .		harace b
22-			The same		‡			Danier Fra
24-	(CL) sitty clay states low tomas plastic, very. Stiff to hard, very mist, loyalife light cultivish-brown	· ·	er mangle		+			Denver for weathered Ivilling becomes smoother at 23 feet
25	weathered Claystone				#			
26-					1 1/4	5	19 36 59/51	PIO=60-858pm
27-	(CH) silty clay share; highly plustic, very stiff to blank, very mist, loyably				1	,	13	Demer Fm Corc rum#1
28	light gettings = 50 and		. j		- 7	2 4		
29-	- Claystone		·		‡		1	
30-					1	_	:	
31-	_				+			Bettom of boring of 30 ROST

PROJECT NO. 89 MC114A

HOLE NO. LSB-32 COE D.O.1 Woodward-Clyde Consultants PROJECT NAME. WOHING LOCATION LIME SETTLING BASINS DATE STARTED COMPLETION DEPTH 4 DHILLER R. Albritton LAYNE-WESTERN CILE 750 W/6-5/8"00 #SA UNDIST. HO. OF HOLLOW STEM AUGERS FIRST 7.0 TYPE OF PEHFOHATION LOGGED UY CHECKED BY SIZE AND TYPE OF PACK FIIOM 10 S. morrissette FROM TYPE OF SEAL 1041.5 FT 6 Posts UEETH V REMARKS DESCRIPTION nslel latio (Drill Rate, Fluid loss, Oder, etc.) a edian sunl/silt (SM) si Hy SAND, fine-grained, poorly-graded , subangular to subrounded y moist, loye 5/3 brown, growelly from 0.0 to as Fi. 575 3 PIO=ND Marco History becomes love 4/6 dark yellowish -brown and slightly less sitty PIO=ND TSS water enters (SP) SAND, fine-grainely poorly SM graded, subrounded medium dense, wet, 10/25/3 brown, with Allwium İSSIA PID=ND a truck of si 9 (SM) 5: Hy SAND, fine-grained, poorly.
graded, dense, wet, loyes/3 Allwium 5 PID=ND ISS 14 14 " 12 13. PROJECT NO. 89MC114A

SHEET /

		GHAPH	C LOG		: 1	54	ин	£S.	
SC PTH (FT CT)	DESCRIPTION	Lithology	Plezomeler Jesteitetlor	Conten	F183541	irse Na	F : 7. !!	2 (G	REMARKS (Drill Rele, Fleid less, Odor, etc.
14	(hat or Sm) sounding SUT as ity SAND,	7-/-	,		-	-			Alluvium
15-	non-plastic, fine-grained, poor/y gradel store, melium dense, wet, loyes/3 brown, with trace of clay.		,		1	-	+	_	
16-	loyes/3 brown, will trace st clay.	111			+	55	18	10	PID=ND
10-					‡	-	+	9	
17-			·		1				
18-	(m) stightly sandy Sut, non-plastic,				‡	.			Allusium
	sand, medtum dense, very moist,	1/1/			‡				
19	10 yrs/3 browng ivon onlde stains 5 ilty Sand				1				
20	-				-	$\dashv$	8		•
21					====	:5/	8	11	QN=O±9
					-	-	╀	-	
22-	Sm) Sitty SAND, fine-grained, poorly-	HIH			#			,	41/wium
23-	Sm) sitty SAND, fine-grained, poorly- graded, medium-lense, very moist to wet, 10 yr4/b dark yellowish-brown	1.111	Manage .		+				
24	gollowish - brown				-				
#					‡	-			
25-1	(CL + CH) slightly sandy silty clay				-		9	I	Senver Fm.
76	to measure plastic, very				15	5 16	1	0   5	slightly weathered DIO = ND
1 T	moist 2 toype 2.546/4 light		· .		+	+		1	:
27 <del>+</del>	Weathered Claystone				T				
28 ‡	Weathered Curys 1511				+				
£9±					+				
+								.	
30-1-	becomes 2.546/2 light brownish				-		11		D=0=10
3/-	TARLE MICHAEL ALCOHOL LINES		(1) (1)	1.	22	B	3	6	
12-	oxide strains, weathered & blocky				200			7	COKE MUN#/
	NO. 89MC11411		<del></del>	- <b>-</b>	.:.€ :	_ _ _		_'	SHIFFT 2 OF 3

DRING LOCATION Sec. 36			ION AND DATU	M ————————————————————————————————————	
	R. McKay	DATE S	NISHED D/	26/9	10 6/27/90 ISAMPLER T. T.
RILLING EQUIPMENT CME 75	/		TION DEPTIL	46_	SUNDIST.
PULLING METHOD Hollow Stem DRILL BIT		NO. SAMP			COMPL 24 HRS.
ZE AND TYPE OF CASING 4 in PVC	•	WAT	ER FIRST		
PE OF PERFORATION 10 Slot FROM 1	5,7 10 25,7	T. LOGGE	) BY		CHECKED BY
ZE AND TYPE OF PACK 10-70 FROM 15	14 1025,75	・	Terry		
PE OF SEAL Bentonite FROM 11	,5 10 15.4 F	ባ ''	(/		
	GRAPHIC		E SAM	PLES	PID PPM
DESCRIPTION		romeler p	Para S	2 4 E	(Dritt Rate, Fluid loss, Odor, e
	ans!	elelica * {	a L	P	(orall vidual) that a solid state of
+ 6 1 11 14 . day and	1		T		
= Sand, slightly clayer, medium = to fine sand, medium dense,	' K . ' Y		1 ± 1		i
+ to time sand, medium dense,	- 34	-   .	1 +		
I moist, dark yellowish brown	\si		1 1		
(SE) 10YR 4/4	1.7		1 ‡ 1		
+ (30) 101K 4/4	\\\\\\\\\		1 + 1	6	
\$ Silty			1 1 1	1 -	$I - N \mathcal{V}$
‡ "'/	Ne.		1 1	8	
+			1 ± 1	5	
#	'A'	1	1 ± 1		
+			1 + 1		
† <b>‡</b>	*	1.	<del> </del>		
, ± , , , , , , , , , , , , , , , , , ,			Ŧ	L	
+	2		IFI	4	
			1 7 1	3	ND
+ Sand, medium to fine sand,			1 + 1	4	
ilty, loose to medium dense,	1		1 7 1	7	
1 still wint with		1	1 ‡ 1		ı
I slightly moist, yellowish brown			1 + 1		
(SP) 10 YR 5/4	1 3 3	- 1	‡		
			1 1	4	ND
?手				3	$  V V \rangle$
The state of the s			1 1	3	
<b>/</b> ‡			1 + 1		
·‡		- 1	<del>]</del>	1	•
‡ Clause and	1/1.		1 <u>I</u>		
+ Clay, very sandy, medium	V: /		IFI	4	
stiff, slightly moist, yellowis	红 / :		<del> </del>	6	ND
+ brown (SP) 10 vo = 111.	1		1 ‡ 1		
brown, (SP) 1048574 (SP) 10484/3	. /		‡	6	
t 0154/3	/				
·+	Y. /		#		
`‡			1 ± 1	1	
,‡			1 ± 1		
3 <del>+</del>	1.1		III		
			1 T I		1
‡			1 1		•
<u>,                                    </u>			±		•

PROJECT NO. 2050 89MC1/4A

SHEET\_\_\_OF\_3

7.B

₹E		GRAPH		:3	اؤوا	설	= 4-8-	MEMARIS IN
PET TE	DESCRIPTION	Lithology	Plezometer Inetailation	<b>≱</b> 5	E Q	4	2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2	(Drill Rate, Fluid tess, Oder, e
1	-	1/.			1	•		
#		·://			Ī			· ·
Ŧ	• •				‡	$\exists$	6	*.
Ŧ		;/			Į		8	ND
Ŧ					ŧ		8	
ŧ					Ī	4		
Ŧ		X			‡			
土		`		- 1	Ī			
‡	Sand, silty, wet, dense		- 1		Ŧ			•
Ξ	to very dense, grayish	-			Ŧ			
ŧ	brown, 104R5/2 (SP)	; ; ^		- 1	ŧ			
‡					+	$\dashv$	5	
Ŧ					Ŧ		,,	ND
‡					+		14	,
ŧ					+	-	7	
-	•	10.			+	<b>'</b>		
Ε,				1	Ŧ			
E		2			Ŧ		ı	•
ŧ_		1,2			±			
‡	Clay sand very most	125			‡	Ш		
Ī	Clay, sand, very moist, stiff, yellowish brown				1	11		
ŧ	10 YR 5/4 (CL)				ŧ		3	ND
E	1017 (24)	: 1			1	$\parallel$	7	$N \mathcal{V}$
ŧ		×. ;/	j		1	-	9	
+				ł	‡			
Ŧ					Ŧ			
-					‡			
‡	Weathered Sandstone,				ŧ			
+	clayey, silty, medium to fine sand, layered, hard	/-			‡			İ
Ł	tine sand, layered, hard				‡			
F	to very hard, thin interboded siltstones 41 inch, grayish				Ŧ	1 1	6	
<u> </u>	SITSTONES 4 Inch, grayish				Ī	П	24	ND
F	brown, 104 R 5/Z (SC)				‡	1 5	0,4	

Denver Formation

89 MC114A

PROJECT NO. .

(FEET)	DESCRIPTION	Lithology		Woter	Pletomet Defe Type Na.	Recor. fi	Parette Perist (Blows 6 h)	PIREMARIES PPM (Drill Rate, Fluid loss, Odor, etc.)
2		1.			ŧc	Ť		
3 ‡		1			10 R			
4		1	·		1	-		
5 =			• .		‡			٠٠.
					<del> </del>			
7 ‡					1			
3 =			<b>د</b> ۱۸۸		+			
9 =					1			
			The state of the s		1		20 33	5.7
1	Claystone sandy silty		and the same of		1		38	911
4	slightly moist, slightly blocky,				+			N D
+	Claystone, sandy, silty, slightly blocky, hard, interbedded siltstones and sandstones, dark grayish brown, 104R4/2-				†OR			, <i>NP</i> ; .
+	(CL-CH) Denver Formation		,		It's			
+					+			·
5					-			·
+					1			
+					+			
+++++++++++++++++++++++++++++++++++++++					‡			
1					+	П		SHEET 3 OF 3

FOODWARD CLOCATION	36			ELE	VATIO	H AND D	ATUA	4		LSB
	ine Westeri	DRILLER R	. McKa	DAT	E STA	RIED O	61	128/	30 - 06/2	9/30
RILLING EQUIPMENT	16 75		·//CLS			ON DEP	ru ;	43.5		rry
ANLING METIND Hal	low Stem	DHILL BIT		5/	NO. O	s DIS	I.		UNDIST.	· • • .
IZE AND TYPE OF CASING	4 in PVC				WATER		IST C	7.5	COMPL 13,3 124	HRS.
YPE OF PERFORATION 1		FROM 19	9 10 29.9		GEO				CHECKED BY	•
IZE AND TYPE OF PACK	10-20 Sand	FROM 1	4 10 21		T. 7	Terry	/		•	
		FROM )	10 . 14	FT		/				
Bento	nne	100 10	GRAPHI	LOG		P :	AMP	LES	PID PF	PKI.
	DESCRIPTION	•	Litholegy	iezomeler skalielien	2 ¥3ler Onleat	Type Ne	Recorde	Panetre Bossi (Boss)	REMARKS (Drill Rate, Fluid loss	, Oder, elc.
10 YR 41	511ty -		* " * " . "					3 5 5	ΝD	
₹ (SP), 10	ty, clayey, release, brown 10	et:				*******		3 6 6 3 4 4	ND 67	
						<del></del>		3 4 2	45	
(Next Pa	age)					+++++++++++++++++++++++++++++++++++++++				
DJECT NO. 891									SHEET_/_	2

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A22-72

		GHAPIII	C LOG	-=	<u> </u>	SAMP	LES	PID PAM
######################################	DESCRIPTION	Lithelogy	Pleasme for Jestol fet los	P S	Pletten Ded	Recor.		(Drill Mole, Fluid less, Oder, etc)
74	Clay, very sandy, very	/, .,			1		12	ΝD
5	stiff, wet, grayish brown, wet, (CL), sand zones,	·/.			+		17 14:	ND
· Ŧ	10 YR 5/2, pale brown	·/·			Ī	11		
16 🛨	10 YR 6/3	;,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,			‡		. •	
17			• •	٠,	1			
10 #					1			•
18 <del>+</del>					Ŧ	$\ $		
19#			-		+		7	NP
20					1		13	,
* ‡							13	.n
2/ <del>]</del>	·				I			·
22‡				1	+			
72 +					1			
23+		1.7	)		ŧ			
24+	Clay sandy, silty, very	X			+		7	
25	Clay, sandy, silty, very stiff, moist, light yellowish				1		11	ND
#	brown (CL) /104R674	7/			#		12	
26 🛨					=			
27					1			
Ŧ			,		‡			
28 🕇					Ŧ			
29 🗜					+		9	
30+	Weathered Claystone, very				‡		13	ND
+	weathered Claystone, very stiff, moist, dark reddish				· ‡		14	
31+	brown, (CH)				1			
32					1			
PROJECT	NO. 89MC114A							SHEET 2 OF 3

**BED:30**15

DESCRIPTION LIthology Plezometer See 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2	PID PPM
The survey of th	III Role, Fluid loss, Odor, etc.)
DESCRIPTION  Lithology Plezometer 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5	
32	
# Sandstone, siltstone, interbedded #	•
33 + gray, moist, nara, wet zones 1.	
10YR 6/1 (SP)	
	<u> </u>
34+	37
35 <sup>+</sup>	
	- 0
	29
[36 <del>+</del>	•
37 <del> </del>	
	,
38+	
39‡	<b>~</b> .
	3
40 ± 1   00   R   F   1   00   R   F   1   1   1   1   1   1   1   1   1	
140 ± 1   R	
1 <del>1</del>	
$\mu$	
#  <del>                                   </del>	
42 Claystone, yellowish brown moist, hard, 104R5/4 (CL)	!
42+ Claystone, yellower brown	
1 moist, hard, 104R3/4 (CL)	
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<u> </u>	
PROJECT NO. BOME 114A	SHEET 3 OF 3

loodward-Clyde Consultants PROJECT NAME	asc	<u>-</u>	D- 9	<u>o.</u>	<u> </u>	HOLE NO. LSI
ORING LOCATION LIME SETTLING BASINS.	ELEV	VATION	AMD	DAT	UM	
RILLING AGENCY LAYNE WESTERN DHILLER M. WALKER	DATE	STAI	HED		7-1	2-90
THLING EQUIPMENT ONE 750 W/ 6-5/8" HSA		PLETIC		EPTH	15.5	SAMPLEH31180 Split
HULLING METIKOU Hollow Ston auger UHILL OIT	SAL	O. OF	5	DIST.	4	UNDIST.
IZE AND TYPE OF CASING	W	ATER		FIRST	13	COUPL M 24 INS.
YPE OF PERFORATION TO		SEU L	ΙY	٠		CHECKED BY
IZE AND TYPE OF PACK FINM 10	FT. C	ha	cci	SSE	THE	
TPE OF SEAL GROUT FHOM 0 10/55	<del>-</del> 17	7	-, ,			
GNAPHIC			-		4PLES	
	Plezomater	¥	23	2	Personal Personal (Secon)	REMARKS. (Drill Role, Fluid loss, Odor, etc.
55	insidiation	-0		2	2 2 2	Cottat Mana, Fano Soci, Gata, Til
> (Sin) silty SAND, fine-grained, pour/y		7	1		3	Fill
I wedel a melium delle, moist,			1	SS	73	
1 10yex/3 brown Fill			4	٦	5	Fill/sludge PID=ND
(Specotce) daying silty saro to souly	-/1	- 1	Ŧ	_	-	PIDEND
sity capy, fine grants			Ŧ			
- Fill poorly graded medium			Ŧ		1	
dense, moist, 547/1 light			Ŧ	- 1	}	
+ gray to 546/1 gray	/~		+	.		
: Bm) sitty SAND, fine grained grow/y	. 1		Ŧ	- 1		F:11
graded, medium denseg moists !!			Ŧ			
gradel, medium denseg moists 104k4/3 brown to dock brown			7		. 3	
# //			+	35/1	4	DIO=ND
4	1		7	ارد	9	•
主	the street sections of		7_	4	-	
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+ 11111			+	1	.	
± //			‡.			
± . 11911			#			
- Gecomes 10425/4 yellowish-brown !!			+			
‡ 13 1111			‡			
<u>+</u>	-		1			water entars
± [Li]			#			ATD
4   FMI	1		#		- 1	• • •
	- 1	1.				
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JECT NO. 89MC/144						SHEET / OF 2
VV 4. C 11(1 A						

_			IC FOR	:5	-   -	SAM	1	REMARKS
(FEET)	DESCRIPTION	Lithology	Plezomeler Installation	Ş Ş	O Sign	Print f	2 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1	(Orill Rele, Fluid less, Oder, e
1	- SAME: (SM) Silty SAND, fine-graine	471			-	7		Fill (?)
	environated very loose to			·	15	5 16	2	P=D=2.0 ppm
F	- loose gwet y 10 yr 5/4 yellowish-brown	3114			#	.	3	P±0=2.0 Fr.
#	eyellowish-brown	٠,			-	-		Bottom of bovin
7	-				=			Bottom of bovin
#					‡	Ш		
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-		1		-		1_		SHEET 2 OF 2

Noodward-Clyde Consultants	PROJECT N	IAME	45	E	D,o		HOLE	NO.
BORING LOCATION LIME SETTING			ELE	VATIO	N AND DA	TUM		
DRILLING AGENCY LAVNE WESTERN	DRILLER M.	WALKE	2 DAT	FWI	RIED	7-12.	-90	1
DRILLING EQUIPMENT CHUE 750 W/6-			COM	የኒርፕ፣	ON DEPT	1,,,		00 splitspa
DHILLING METHOD Hollow Stan augus				NO. O		7	COLIPL.	24 BRS.
SIZE AND TYPE OF CASING 0				ELEV.		st 12.5	CHECKED BY	
TYPE OF PERFORATION	FHOM	10		GED		-		
SIZE AND TYPE OF PACK	FROM -	10	<u> </u>	pho	ee:ss	4 116		
TYPE OF SEAL . GROWT		10/5-5			h -   5	AMPLES		
DESCRIPTION DESCRIPTION		Lithology	Plezometer Installation	Water Cantent	Pletone Pate Type No	Record. Recist. (Bows/	(Drill Rate, FA	MARKS id loss, Odor, etc
O - (SIM) claying 5: Hy SAND, fin	moists 547/1	M			-45	15 10	Fill /slu P=D=	Age DD
(Sm to 50) silty samo	/ 1/1				+	7	Fill .	
SAND, fine graced, medium lesse, moist, to dark brown	poorly gradedy.				‡			
3 to lark brown Fill					‡			• •
<b>∮</b> ‡					-	1/7		. 2
	1				<u> </u>	17 5	P=0=	٠٠٠ (1 <del>7-</del>
. ‡ - <del>‡</del>			A COMMANDA		#	,		·
7 ‡					‡			
γ±.	and the same and		,		‡			
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10			·		<u></u>	18 8	ρ <b>∓</b> 0=	au.
<del>-</del>	•				1	-		
(Sm) silty SAND, fine	redium				+		Allwin	in
poorly graded on lanseg wat gloy gellow ish brown	R5/4				#		water.	entas 12.T)
					1			
7		4						
30 IECT NO 89 MC 114A	7						SHEET.	OF 2

89mc114A

PROJECT NO.\_

		GRAPII	ic Log		<u> </u>	AMI	LES	
OEPTH (FEET)	• DESCRIPTION	Lithology	Piezomeler Jastolistion	Wo: e f	Fictoria Dota Type No.	Arcm. fi	A THE COLUMN	REMARKS (Drill Role, Fluid lass, Oder, etc.
14-	- SAME: (Sm) silty SAND9 fine - grained, poor / graded 9 melium denseg wetg 10YRS/4 gelboish-brown						9	Allwinn
15	grained, poor/y great				<u>‡ss</u>	VC	10	6±0=00;
1 ‡	10/R 5/4 gellowish - brown.	111			-	H		Bottom of boving
16-		·						at 15.5 fort
17				.	1			
1' ‡			. 1	-	+			
18#			<i>!</i>		+			
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1/7#					I	.	-	
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25					#		1	• • •
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27				-	Į			
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28				-	-			
25					11			
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32+					-			
‡								
3/+				•				
32				-	-			
OUECT I	NO. 89mc114A							SHEET ZOF Z

HOLE NO. MI-01 Woodward-Clydo Consultants PROJECT NAME \_ BORING LOCATION -90 Western NO. OF Auger DHILL DIT 24 IIRS. CHECKED DY LOGGED BY FHOM T. Terry 10 FI. FHOM . SIZE AND TYPE OF PACK 10 FT FHOM TYPE OF SEAL Grout GRAINIIC LOG Pleton DESCRIPTION (Drill Rate, Fluid loss, Oder, etc.) Fill, clay, sandy, gravel, bricks, as phalt, very moist, brown 2 2, Drup Sand, silty, clayey, brown, very moist to wet, medium 3 dense 10. 3. 5 11 8 Weathered Claystone, siltstone and sandstone, blocky, stiff crumbly, dark olivegray, 12. dry

400 <u>220</u>888

A22-79

89MC 114A

PROJECT NO.\_\_

SHEET 1 OF 2

		GHAPH	וכ נספ	-=	الله الله	TEL .	REMARKS	1
00 PTH (TEET)	DESCRIPTION	Lithology	Piezomeler Instelletion	Wo! Con!	Piezonete Defe Type Ma	Proof.	(Drift Rale, Fluid loss, Odor, et	(c)
						-		-
14+	-				Ŧ			
Ŧ		<b>'</b>	t l		1			
15-					+	16		1
II					‡	6 4	769	
1/2 F					+	7	•	
16 +					‡	8		
					7			1
177					Ŧ		•	
I · I	Claystone, siltstone, sandstone, hard, dry, layered, brown, green				#			
19 ‡	sandstone, hard, dry,			- 1	#			
1' 1	lavered brown areen		.		Ŧ			1
1 ±	rayer ca) Drown, g.		1		Ŧ			
120 <del>-</del>					-	36	34:	-
I I	· ·			1	‡	36 50/5	21	
13, I	•	200		- 1	+	-73		1.
12/ +	·				#			
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PROJECT	NO 89MC114A						J.,	A

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A22-80

Woodward-Clyde Consultants PROJECT NAME -HOLE NO. MI-02 UDRING LOCATION 01 DATE STARTED DATE FWISHED 6-90. OHILLEN DRILLING AGENCY arne Western COMPLETION DEPTH SAMPLEH CME 750 DRILLING EQUIPMENT UNDIST. NO. OF DHILLING METIND Hollow Auger 24 HRS. COMPL WATER . NA CHECKED BY LOGGED UY FHOM YPE OF PERFORATION T. Terry SIZE AND TYPE OF PACK 10 30 FHOM TYPE OF SEAL Grout GHAPPIIC LOC DESCRIPTION (Drill Rate, Fluid loss, Odor, etc. č Clay, little to some sund, dry to moist, brown to yellowish brown, stiff to very stiff ND 3 7 8 12 13 6 12 ND 8 11 12 Sand, silty, trace day, moist, very dense, yellowish brown 10-11. ND 14 7/-18 Weathered Claystone, verystiff moist, blocky, fractured, calcareous, dark yellowish brown, olive gray, olive brown,

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PROJECT NO. .

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SHEET 2 OF 2

ORILLING AGENCY LONG Western   DATALER R. Allbrightton   DATALLER T. 7-16-90.  DIRELING EXCHANGE COMPART   CME 750  DIRELING EXCHANGE HOLDER Auger   DATALLER T. 7-16-90.  DIRELING EXCHANGE HOLDER Auger   DATALLER T. 7-16-90.  DIRELING EXCHANGE HOLDER Auger   DATALLER T. 7-16-90.  DIRELING EXCHANGE HOLDER Auger   DATALLER T. 7-16-90.  DIRELING EXCHANGE HOLDER AUGUST   DATALLER T. 7-16-90.  DIRELING EXCHANGE HOLDER AUGUST   DATALLER T. 7-16-90.  DIRELING EXCHANGE HOLDER AUGUST   DATALLER T. 7-16-90.  DIRELING EXCHANGE HOLDER AUGUST   DATALLER T. 7-16-90.  DIRELING EXCHANGE HOLDER AUGUST   DATALLER T. 7-16-90.  DIRELING EXCHANGE HOLDER AUGUST   DATALLER T. 7-16-90.  DIRELING EXCHANGE HOLDER AUGUST   DATALLER T. 7-16-90.  DIRELING EXCHANGE HOLDER AUGUST   DATALLER T. 7-16-90.  DIRELING EXCHANGE HOLDER AUGUST   DATALLER T. 7-16-90.  DIRELING EXCHANGE HOLDER AUGUST   DATALLER T. 7-16-90.  DIRELING EXCHANGE HOLDER AUGUST   DATALLER T. 7-16-90.  DIRELING EXCHANGE HOLDER AUGUST   DATALLER T. 7-16-90.  DIRELING EXCHANGE HOLDER AUGUST   DATALLER T. 7-16-90.  DIRELING EXCHANGE HOLDER T. 7-16-90.  DIRELING EXCHANGE HOLDER T. 7-16-90.  DIRELING EXCHANGE HOLDER T. 7-16-90.  DIRELING EXCHANGE HOLDER T. 7-16-90.  DIRELING EXCHANGE HOLDER T. 7-16-90.  DIRELING EXCHANGE HOLDER T. 7-16-90.  DIRELING EXCHANGE HOLDER T. 7-16-90.  DIRELING EXCHANGE HOLDER T. 7-16-90.  DIRELING EXCHANGE HOLDER T. 7-16-90.  DIRELING EXCHANGE HOLDER T. 7-16-90.  DIRELING EXCHANGE HOLDER T. 7-16-90.  DIRELING EXCHANGE HOLDER T. 7-16-90.  DIRELING EXCHANGE HOLDER T. 7-16-90.  DIRELING EXCHANGE HOLDER T. 7-16-90.  DIRELING EXCHANGE HOLDER T. 7-16-90.  DIRELING EXCHANGE HOLDER T. 7-16-90.  DIRELING EXCHANGE HOLDER T. 7-16-90.  DIRELING EXCHANGE T. 7-16-90.  DIRELING EXCHANGE T. 7-16-90.  DIRELING EXCHANGE T. 7-16-90.  DIRELING EXCHANGE T. 7-16-90.  DIRELING EXCHANGE T. 7-16-90.  DIRELING EXCHANGE T. 7-16-90.  DIRELING EXCHANGE T. 7-16-90.  DIRELING EXCHANGE T. 7-16-90.  DIRELING EXCHANGE T. 7-16-90.  DIRELING EXCHANGE T. 7-16-90.  DIRELING EXCHANGE T. 7-16-	DRING LO	rard-Clyde Consultants P				ELEVA	TIOH A	DAT	UM		n .
Sand, silty, medium to fine    Clay, sandy, fine sand, moist, large of cash from (CL)   104R4/2, 104R5/3, 104R   104R4/4, 104R5/3,	RILLING A	10 L	DRILLER R.	Allbrig	htton	DATE !	STAULEL	7	-16-		· 1/4/4
Sand, silty, medium to fine  Sand, silty, medium to fine  Sand, silty, medium to fine  Sand, silty, medium to fine  Sand, moist, loose, dark  yellowish brown (SM)  10 YR5/3  Sand, calcareous (CL)  10 YR 4/4, 10 YR5/3;  5 Y5/3  Sand, calcareous (CL)  10 YR 4/4, 10 YR5/3;  5 Y5/3	MILLING EC		<del></del>			COMPL				1	Terry
Sand, silty, medium to fine sond, moist, losse, dark yellowish brown, brown (SM)  Clay, sandy, moist, very stiff, dark yellowish brown, brown, olive, trace sand, calcareous (CL)  10 YR 4/4, 10 YR 5/3;  5 Y 5/3  10 PR 100 NA PRIOR 10 PR. LOGGED BY  T. Terry  CHECKED BY  T. Terry  T. Terry  CHECKED BY  T. Terry  T. Terry  CHECKED BY  T. Terry	HILLING M	Hollow Auger	DRILL DIT			SAMP	LES	<u>i</u>		<u> </u>	124 400
Sand, silty, medium to fine sond, moist, loose, dark yellowish brown (SM) 10 YR5/3  Clay, sandy, moist, very stiff, dark yellowish brown, brown, olive, trace sand, calcareous (CL) 10 YR 4/4, 10 YR5/3; 5 Y5/3  T. Terry  Tollians  T. Terry  Tollians  Tollians  T. Terry  Tollians  Tollian	IZE AND					WAT	EV.	FILLS	8		124 1003.
Sand, silty, medium to fine sond, moist, loose, dark yellowish brown (SM) 10 YR 5/3  Clay, sandy, moist, very stiff, dark yellowish brown, brown, olive, trace sand, calcareous (CL) 10 YR 4/4, 10 YR 5/3; 5 Y 5/3	YPE OF PE	ENFORATION NA	FHOM	10	FT.	LOGGE	D OY			CHECKED DY	· · · · · · · · · · · · · · · · · · ·
Sand, silty, medium to fine  Sand, moist, loose, dark  yellowish brown (SM)  10 YR 5/3  Clay, sandy, moist, very stiff, dark yellowish brown, brown, olive, trace sand, calcareous (CL)  10 YR 4/4; 10 YR 5/3; 5 Y 5/3	IZE AND	TYPE OF PACK N.A	FROM .	10	F1.	7.	Ter	rv	,		
Sand, silty, medium to fine sond, moist, poly promise sond, moist, loose, dark yellowish brown (SM) 10 YR 5/3  Clay, sandy, moist, very stiff, dark yellowish brown, brown, olive, trace sand, calcareous (CL)  10 YR 4/4, 10 YR 5/3;  5 Y 5/3	PE OF SE	EAL Grout	FROM O	10 24	FT		, - ,				
Clay, sandy, fine sand, moist, medium stiff, dark grayish brown (CL)  104R4/2, 104R  Sand, silty, medium to fine sand, moist, loose, dark yellowish brown (SM)  104R5/3  Clay, sandy, moist, very stiff, dark yellowish brown, brown, olive, trace sand; calcareous (CL)  104R4/4, 104R5/3;  545/3		••			Piezos	>	Sale A	2	APLES A SECTION OF THE PROPERTY OF THE PROPERT		
Weathered Claystone, verystiff		Sand, silty, medium to sand, moist, loose, d yellowish brown (SM) 10 YR5/3 Clay, sandy, moist, v stiff, dark yellowish brown, brown, olive, sand, calcareous (CL) 10 YR 4/4, 10 YR5/3, 5 Y5/3	ofine ark rery h trace						44 21.2 121213 912	700	2

PROJECT NO. 89 M C 114A

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reer	DESCRIPTION	Lithology	Plezomater installation	Woter	Piezonei Dels Type Ng	Prote fi	REMARKS (Drill Role, Fluid los PID PF	oder,
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					<b>+</b>	50/5		
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_					# .		•	
	Claystone, hard, moist,	A.			Ī			
	Claystone, hard, moist, slightly fractured, trace sand, dark brown, layered (CH)				‡	11.5		:
	5Y4/3,10YR3/3				+	38	ND	
		A STATE OF THE STA			‡	50/5 5	$n\nu$	
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ORING LOCATION				E_R/	IELEVATI	DH AND U	ATUM		n ·
	Sec 01				DATE SI	ARIED		2~90	7-12
RILLING AGENCY	Layne Wes	tern   DHILL	EH R.MC	Kay	DATE FM	ISHED		SAUPLER T	7770
HILLING EQUIPMENT	CME 75	- On Ioniti	naT.	. /				UNDIST.	Terry
ILLING METIKU		ger   onic	. 811		NO. SAMPL			COMPL	24 HAS.
ZE AND TYPE OF	1713		10	FL	LOGGED	/.		CHECKED BY	<u> </u>
PE OF PERFORATI	IYA	FHOM				_	,		• • ••
ZE AND TYPE OF	PACK NA	FROM	. 10		1. /	erry			
PE OF SEAL	Grout		0	1715	-		AMPLES		
4661)	DESCRIPTION			ology Piero	meter >0	Pictor Property A ACT	Pentite Pentite (Sery/ 6 In)	(Orill Rate, Fluid	ARIKS d lose, Oder, e PPM
Clay brown 10 Y	stone, little, hard, moder, stratified dark grayish, reen, blue, or	alcareous very stiff. CL ist to ve dimostly.				\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\	3 87 554 733 483		D -Auger Head Spa

PROJECT NO. 89 MC114A

SHEET\_LOF 2

HOLE NO. M1-05 Woodward-Clyde Consultants PROJECT NAME RMA DORING LOCATION 90 Western M. Walker avne COMPLETION DEPTH 750 NO. OF UNDIST. DHILL BIT Hollow Auger 24 HRS. FIRST WATER . LOGGED UY CHECKED DY FHOM TO FROM . SIZE AND TYPE OF PACK T. Terry FHOM O 10 25 TYPE OF SEAL GHAPHIC LOC Troe No. DEPTH (FEET) ¥ater Onten DESCRIPTION (Drill Rate, Fuld lass, Odor, etc. Sand, clayey, silty, dry towet, medium dense to very dense, brown, yellowish brown (SP) 10YR4/3, 10YR5/8 9 10 PPM 10 YR 5.14 II14 18 PPM 4,6 6 6 8 В 15 9 10 13 133 PPM 19 16 weathered claystone with interbedded siltstones and sandstanes, very stiff, moist to very moist, light olive gray, light grayish brown 13. (CH), 5Y6/2, 2.5Y4/2

A22-87

89MC114A

PROJECT NO.\_

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A22-88

89MC114A

PROJECT NO.

SHEET 2 OF 2

Woodward-Clyde Consultants	PROJECT 1	NAME	Ø€	D.	0.	1_	HOLE NO. M-1
BORING LOCATION M-1 PONOS			ELEV	ATION AA	D DAT	UM	4
DRILLING AGENCY LAYNE -WESTERN	DRILLER .	Albritton	DATE	STARTEC	•	7-13	40
DHILLING EQUIPMENT CINE 750 W/6-5/8'	' HSA		COMP	LETION	DEPTH	28.0	SAMPLER 3"00 Split saw
DHILLING METHOD Hollow Steen Augus	DRILL DIT		SAM	PLES	DIST.	7	UNDIST.
SIZE AND TYPE OF CASING -				TER EV.	FIRST	9.0	COMPL NR 24 HRS.
TYPE OF PERFORATION	FROM	10 F1		EO UY			CHECKED BY
SIZE AND TYPE OF PACK	FROM -	10 FT	1 6 1			-	
	IFROM -	1000 FT	124	user	שננו	116	
TYPE OF SEAL . GROUT	1 0	28.0					·
DESCRIPTION		GHAPPIC L	.06	- 2	9	UPLES	REMARKS
DESCRIPTION			riolion 3	Pieton Peron	7	Peretra Resist.	(Drill Rate, Fluid loss, Odor, etc.
		1 1 2 1		4	Ĭ.	& 4 am	
O (sm) gravelly silty SANDs fire graves	inery forty	le de la			- 1		Topsoil
1 +(Sm) slightly claypy silty SANE		H-1-1-1	- 1	1 1	- 1	1.	Fill(?)
1 = Soll since approximate	Q. mediun				-	1 .	1 111(-)
fine-grained, poor /x grade dense, duy to moist, loye	4/2 Dark	11111	- 1		:	1	
1 I dense, and to move is	1/20	, *		1 4	- 1		
2 - grayih - brown		13.14			:	1	
_ ‡		1.1.1		1 1		13	
3‡		1111	15	1 -	-	19	PID=ND
Ţ.				+	SS	8	1-10-1-
<b>√</b> ‡		f1-111	<u> </u>	$\mathbf{I}$		0	
/ <b>T</b>		[ ] - [ - ]		1 7			
# /	. 1	:1111		1 7			
5‡	Company of	F1:41	- 1	14	-	-	•
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. ‡			. ' [	‡	SSM	A 4 1	DIO=ND
<del>-</del>	$ \setminus$ $\setminus$			1 7	-	4	
‡		[1-1-1-1		‡	-		
) <u> </u>				1 #		1 1	
=(Sporsm) slightly sitty or sitty	SANDS			lt	- 1		Qeolian soul/s:14
fine-grainel, pour/y gradely >	nbougular	1.11.1		I		0	
to subrounded, medium den	se, moist,	rank and		1 +	-	10	0=0 = 110
10486/4 light yellowish-brown				1 45	SSIR	0	QIN = OIQ
\$ 1 10 1 10 1 1 1 1 1 1 1 1 1 1 1 1 1 1		1.5		II		/	A lous
				1 ‡			ATD (measures)
	44	7 7	1	1 ‡			
o + (SC or CL) elayon SAND or sound	y sitty	·/.		1 ±			Allwium
t capy, fine-grained , poorly qu	radely			1 1		8	
Medium desiles havis	7		- 1	to	SW	10	OTO SUO de las
10yr5/4 yellowish-brown with	1048/1 V			F	219	10	PID=NO to 18P
white motting				I	$\dashv$		
$\sim 1$		1-	1	I			
<del>'</del>	. 1			17			
Ŧ				‡			
5-T(21) 11 01 514 6121 1-11	Lin Davia		1	1 -			Allavium
+ (CL) sandy Sitty CLAYs low plas stiffs mist to very mist + 1041	26/2			1 7			your tel Ledwik)
L' light brownish -gray with populi	hite melling -			‡		1	y ( )
7			1	-	11	- 1	

PROJECT NO. 89mc/144

SHEET OF 2

A22-89

		C	IC 100		1.	54	MPL	S	
0 (FEET)	DESCRIPTION	Lithology	Plezometer Inetaliation	Water Content	Pistonstier Deta	THE NE	Paure, fr	1 (E	REMARKS (Drill Rale, Field lass, Odor, etc)
14-	(CL) Sandy silty chan stace, low plastice have noist to very mist, 10/R5/1 gray, very blocky and crumbly, with a trace of				11111111		11		Denver For (weathered)
16-	course gravel  Weathered Claystone		· [			SS	8 8	31	01 = 01q
17-			·						
18-									
20	- becomes loyelle dark grayish-bown				+++++++++++++++++++++++++++++++++++++++	-	28		
21	with less sand and no grand					\$5 /		4	PID=15ppm
22					+				
23					# 1				becoming Stiffer to Orill Denvertined
25	(CL) slightly sandy sitty capy States, low-medium plasticy moist, very hardy 10 yet/2 outgrayish				177	510	28	'	PID =67-213ppm ASH3 = 0.5 ppm Driver = NDH Curerum #1
26	with iron oxide staining				+0	2			care von 417
27	Claystone				+ F	106-4			
28					+ + + + + + + + + + + + + + + + + + + +			1	Buttom of bowing
29								0	t 28.0 teet
30-1- 31-1-					+				
32 -				-	‡				
PROJECT	NO. 89mc114A								SHEET 2 OF 2

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PROJECT NO. \_\_

CHI Slightly sand silty carry, highly prout street fact grains and sand the prout street fact grains and the prout street grains and the prout street grains and the prout street grains and the prout										
THE LOCATION MO DATUM  LETTER LOCATION MO DATUM  LETTER LOCATION MO DATUM  LETTER LOCATION MO DATUM  LETTER LOCATION MO DATUM  LETTER LOCATION MO DATUM  LETTER LOCATION MODELLET TO LOCATION  LETTER LOCATION  LE	to action of Charles Consultants of Charles	DPO JECT J	NAME		Coc	- 1	).0.	1	HOLE NO. M-	øφ
LELLER CONTROL TYPE—WESTERN   SOUTH FOR A PLANTAGE   STATE STATES   STATES		ROJECT	WANE _						4 1/4 14	1
LILLIES WELLIES HOLLIES TO W/ 6-5/8" HIGH  CLINES WELLIES WITCH DECEMBER  AND TYPE OF PACK  FOR THIN 10 PECCENT TO W 15 L  FOR THIN 10 PECCENT TO W 15 L  FOR THIN 10 PECCENT TO W 15 L  FOR THIN 10 PECCENT TO W 15 L  FOR THIN 10 PECCENT TO W 15 L  FOR THIN 10 PECCENT TO W 15 L  FOR THIN 10 PECCENT TO W 15 L  FOR THIN 10 PECCENT TO W 15 L  FOR THIN 10 PECCENT TO W 15 L  FOR THIN 10 PECCENT TO W 15 L  FOR THIN 10 PECCENT TO W 15 L  FOR THIN 10 PECCENT TO W 15 L  FOR THIN 10 PECCENT TO W 15 L  FOR THE WELLIS SHAPE SHAPE WELLIS WELLI		DRILLER R.	Albritto	4	DATE F	MISHED				1
LINE WITHOUT COMME  READ TYPE OF CASHING  FIRST  COMPT 2 PROMISE  FOR FAILS	1 4 4/1				COMPLE	TION	OEPTH	26.0		
E AND TYPE OF CASHIO  FOR PREPARATION  E AND TYPE OF PACK  FOUND  DESCRIPTION  DESC	HILLING METHOD Hollow Stem Angers	DRICE BIT			SAMP	LES	<u> </u>	6	1 1112	1
E OF PERCE TO THE CONTROL TO THE SAME STATE TO SEAL SCOTT TO THE SAME STATE TO SEAL SCOTT TO THE SEAL SCOTT TO THE SEAL SEAL SCOTT TO THE SEAL SEAL SCOTT TO THE SEAL SEAL SEAL SEAL SEAL SEAL SEAL SEA	ZE AND TYPE OF CASING				ELE	V.	FIRST		24 1	-
DESCRIPTION  DESCR	THE OF PERFORATION									-
DESCRIPTION  DESCR		IEUON			S. n	ropp	<i>પેડા</i> લ	THE		
DESCRIPTION  LIMBORY PHILODORY  PRIMARY  CONTY GRANDO STATE AND A FIRE AND STATE OF THE RELEASE	- Skout	1 0	GIAPI	UC 10		1.	SAL	IPLES		1
Good of granded strict and Fill  Get clarges sith SANO, fire granded, poorly granded, medium dunse, moist, loyred 2 dark grandsh  brown  Fill  Get slightly sand, sithy copy, highly plastic, stiff, very moist, toyre 2/2 very dark brown with free of fire granded shown with loyre 8/2 white medium pusits loyer/3 brown with loyre 8/2 white medium  Fill  SS & L  PIO = ND  Allowing  SS & L  PIO = ND  Allowing  SS & L  PIO = ND  Allowing  SS & L  PIO = ND  L  Becomes more clarges to 14.5 ft.	DESCRIPTION			1		Plezoner Dete	Type Na	Pendice Beat	REMARKS (Drill Rate, Fluid loss, Odor, etc.)	
(SE) clases sith SAND, five arrivals  poorly agraded, medium dense, moist, loyer/2 dark grapish  brown  Fill  Cety slightly sand, silty clay, highly plastic, stiff, very moist, loyer 2/2 very dark brown with trace of five grained sand  Fill  (SC) clases silty SAND, five-cruised, poorly graded, smedium dense, poorly graded, smedium with loyer 8/2 white mothling  becomes more clayer to 14.5ft.	) (sm) gravelly silty SAND, fine-qu	variety	16191			:			Fill	
poorly graded, medium dense,  moist, loyal/2 deak gragish- brown  Fill  SSIS 9  PID=ND  SSIS 4  PIO=ND  CHI Slightly sandy silty CLAY, highly plastic, stiff, using moist, loyal/2/2 very deak brown with tree of fine grained samo  Fill  (SC) clayery silty SANDs fine-quied, poorly graded, medium dense, poorly graded, medium dense, poorly graded, medium dense, poorly graded, medium dense, poorly graded medium dense, poorly	Toolly granter median australy	grainela	12.1	t		=	:		F:U	
becomes loye3/2 very book graphs.  becomes loye3/2 very book graphs.  brown  SS 18 4  PIO = ND  SS 18 4  PIO = ND  Fill  SS 18 16  PIO = ND  Fill  SS 18 16  PIO = ND  Allwinn  poorly graded medican design  poorly graded medican with  loya 8/2 white mothing  Becomes prove clayes to 14.7 ft.	the state of the s	Luse.	1/:	}						
brown  Fill  becomes loye3/2 very dork grapish.  brown  (cf) slightly sandy silty clay, highly plastic, Stiff, very moists, loye2/2 very deak brown with tree of fine granish sand  Fill  (SC) clayers silty SAND, fine-criedly, poorly gradely medican deaks, proists, loye5/3 brown with loye8/2 white mothling  SSIB 16  Allwinn  SSIB 16  PIO=ND  Allwinn  SSIB 16  PIO=ND	+ to st land the Rack or	agish-	1./4		1	]				
becomes loye3/2 very doork grayish.  brown  (cft slightly sandy silty ccpy, highly plastic, stift, very moist, loye2/2 very death brown with tree of fine grained sand  Fill  (SC) clanger silty SAND fine-cruially, poorly gradely med in deasts, moist, loye5/3 brown with loye8/2 white mothing  Becomes more clarger to 14.7ft.	+ house	1	1:7	1		=	-			
becomes loye3/2 very dork grayish.  brown  (CH) slightly sandy silty CLAY, highly plastics stiff, very moist,  loye2/2 very devk brown with tree of fine grained sano  Fill  (SC) clayers silty SANOy fine-created, poorly graded, medican dend, poorly graded, medican with loye8/2 white mothing  becomes more clayer to 14. Tft.	<b>+</b>		17.1			1		-		
becomes loye3/2 very dork grayish.  brown  (CH) slightly sandy silty CLAY, highly plastics stiff, very moist,  loye2/2 very devk brown with tree of fine grained sano  Fill  (SC) clayers silty SANOy fine-created, poorly graded, medican dend, poorly graded, medican with loye8/2 white mothing  becomes more clayer to 14. Tft.	, <del>+</del> - 11		1.1			1.4	-	]8	070 - 110	
becomes loye3/2 very dork grayish.  brown  (CH) slightly sandy silty CLAY, highly plastic, Stiff, very moist,  loye 2/2 very derk brown with trace of fire grained sano  Fill  (SC) clayery silty SANDy fine-grained, poorly graded greet in dense, poorly graded greet in dense, poorly graded greet in mother loye 8/2 white mothery  - becomes more clayer to 14.5ft.			1	}		1, 3	22	5 9	P10-200	
CHI slightly sandy silty CLAY, highly  plastic, Stiff, very moist,  10 yr 2/2 very deal brown with  tree of fine grained sand  Fill  (SC) clargery silty SANDy fine-grained,  poorly graded medium dease,  proofly graded medium dease,  proofly graded medium dease,  proofly graded medium dease,  proofly graded medium dease,  proofly graded medium dease,  proofly graded medium dease,  proofly graded medium dease,  proofly graded medium dease,  proof y graded medium dease,  proofly grade	<i>(</i> ±				7		_	0	•	
CHI slightly sandy silty CLAY, highly  plastic, Stiff, very moist,  10 yr 2/2 very deal brown with  tree of fine grained sand  Fill  (SC) clargery silty SANDy fine-grained,  poorly graded medium dease,  proofly graded medium dease,  proofly graded medium dease,  proofly graded medium dease,  proofly graded medium dease,  proofly graded medium dease,  proofly graded medium dease,  proofly graded medium dease,  proofly graded medium dease,  proof y graded medium dease,  proofly grade	$\pm$		/	Ì	i	1 1	:		٠	
CHI slightly sandy silty CLAY, highly  plastic, Stiff, very moist,  10 yr 2/2 very deal brown with  tree of fine grained sand  Fill  (SC) clargery silty SANDy fine-grained,  poorly graded medium dease,  proofly graded medium dease,  proofly graded medium dease,  proofly graded medium dease,  proofly graded medium dease,  proofly graded medium dease,  proofly graded medium dease,  proofly graded medium dease,  proofly graded medium dease,  proof y graded medium dease,  proofly grade	- 1 2/2 were dark	gragish -	7		. '	1 =				
CH) slightly sandy silty CLAY, highly  plastic, Stiff, very moist,  loye 2/2 very dark brown with  tree of fine grained sano  Fill  (SC) clarger silty SAND, fine-crimed,  poorly graded, med incomediately,  poorly graded, med incomediately,  poorly graded, med incomed,  poorly graded, med incomed,  poorly graded, med incomediately,  processed in the process of	+ becomes loyks/2 org	0	/			1 3	-	4		
plustic, stiff, very moist,  10 yr 2/2 very lask brown with  trace of fine grainel samo  Fill  (SC) clayer silty samo, fine-crainel,  poorly graded, medium denie,  moist, 10 yr 5/3 brown with  10 yr 8/2 white mothling  becomes more clayer to 14.5 ft.	+ brown	*		· • • • • •		1 1	55/1		PIO=ND	
plustic, stiff, very moist,  10 yr 2/2 very lask brown with  trace of fine grainel samo  Fill  (SC) clayer silty samo, fine-crainel,  poorly graded, medium denie,  moist, 10 yr 5/3 brown with  10 yr 8/2 white mothling  becomes more clayer to 14.5 ft.	+	. •	/		-	1 =	=	7		
plustic, stiff, very moist,  10 yr 2/2 very lask brown with  trace of fine grainel samo  Fill  (SC) clayer silty samo, fine-crainel,  poorly graded, medium denie,  moist, 10 yr 5/3 brown with  10 yr 8/2 white mothling  becomes more clayer to 14.5 ft.	<del>]</del>	*,	/./			‡				
plustic, stiff, very moist,  10 yr 2/2 very lask brown with  trace of fine grainel samo  Fill  (SC) clayer silty samo, fine-crainel,  poorly graded, medium denie,  moist, 10 yr 5/3 brown with  10 yr 8/2 white mothling  becomes more clayer to 14.5 ft.	-		. 9/-			-			<i>-</i>	
10yR 2/2 very lark brown with tree of fine grainel sANO  Fill  (SC) clayer silty SANDy fine-crimely, poorly gradely med in dense, proist, 10yR 5/3 brown with 10yR 8/2 white mothing  - becomes more clayer to 14.5ft.	+ (cxt) slightly sandy silty CCA)	19 highly				1 1		1	Fill,	
Fill  (SC) clayer silty sandy fine-covered,  poorly gradely med in dense,  moist, 10yes/3 brown with  10yes/2 white mothling  SSIB 16  PIO=ND  Secones more clayer to 14.5ft.	I plustice Stitte very mi	pist,				1 7		5		
Fill  (SC) clayer silty sandy fine-covered,  poorly gradely med in dense,  moist, 10yes/3 brown with  10yes/2 white mothling  SSIB 16  PIO=ND  Secones more clayer to 14.5ft.	I 10 yr 2/2 very dark brow	on with				1 7	55/8	16	PIO=0.5 ppm	
Fill  (SC) clayer silty SANDy fine-extinally  poorly graded med in a dense,  proist, loye 5/3 brown with  loye 8/2 white mothling  Becomes more clayer to 14.7ft.	trock of fine grained sa	VO				I		17		
(SC) clayer silty SANDy fine-crimely  poorly gradely medium dense,  moist , loyer/3 brown with  loyer 8/2 white mothling  Becomes more clayer to 14.774.	+					] ‡	十	1	٠,	
10yr. 8/2 white mothling  becomes more clarged to 14.77+.			/:/			‡			A.1. 5	
10yr. 8/2 white mothling  becomes more clarged to 14.77+.	+(SC) clayer sity strong fin	a-grandly	7: 1			‡		1	Allwinn	
10yr. 8/2 white mothling  becomes more clarged to 14.77+.	t poorly grades med at	it				I			1	
becomes more clayey to 14.774.	+ MOISTA JOVES / 3 Drown		//			1 3	27/9		PIO=40	
	I Joyicol Lumite min		/		1.	1 ±	$\bot$	16		
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	- becomes more clayed to	(4.) T+.	1:1			‡	-		I	
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A22-91

PROJECT NO.\_

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Woo	odward-Clyde Constituties (ip) 11(0)201 NAME						100	
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OCPTH (FEET)	- DESCRIPTION	Lithology	Piezometer Installation	N.3.	i a	-	T T	(Drill Rale, Field loss, Oder, etc.)
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	t (co com o co co com)	11-			‡	- 1		Derver Fin
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	+ poorly gradely medium hardy	1. 1	4		Ŧ		18	/ (weather)
	mist, 104R5/1 gray, slightly silty	/			1	SS	e 14	
16-	The stand of the stand	1. 7			1	-	17	9 PID=0.8 ppm
	SANOSTONE with clayery silty sano				£	_	-	
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PROJECT	NO. 0714-1174							SHEET - OF -

Woodward-Clyde Consultants PROJECT NAME RM A ELEVATION AND DATUM BORING LOCATION -90 DHILLER M. Walker DRILLING AGENCY Western DATE EMISSIED SAMPLEH COMPLETION DEPTH Teri HO. OF UNDIST. DHILL DIT Cont. Corina COMPL FIRST CHECKED BY LOGGED UY FROM TYPE OF PERFORATION T. Terry 10 FROM . SIZE AND TYPE OF PACK 10 20 FROM 0 TYPE OF SEAL Gro ut GRAPHIC LO 5.5 2.5 Lithology No. DESCRIPTION Ž (Oriti Rate, Fluid loss, Oder, etc. Fill, clay, sandstone, claystone, blocky, mixed, wet, olive gray, grayish brown, 5 Y4/2, 10 YR5/2 10YR4/2 31.6 10 23 11 12,6 10 6 10 5 16.1 8 10 14 9 10 8. 21.9 13 18 Claystone with thin interbedded sandstone lenses, hard, moist, grayish brown, green, reddish yellow, yellow, light gray, stratified, gravelly 13

PROJECT NO. 89MC114A

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SHEET\_ / OF .2

East	DESCRIPTION LINOIS	Plezometer inciditation	Voter	Piezoneler Dole Type Ma	Mbres Estate 1: 1: 1: 1: 1: 1: 1: 1: 1: 1: 1: 1: 1:	REMARKS (OrlH Rate, Field loss, Odo
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	o. 89MC1/4A					SHEET 2 OF

A22-94

Woodward-Clyde Consultants PROJECT NAME RMA COE HOLE NO. M1-09 BORING LOCATION 01 DHILLER M. Walker 790 18/90 UNILLING AGENCY avne Western DATE FUISHED COMPLETION DEPTH DRILLING EQUIPMENT UNDIST DIST. URLING METHOD HOLLOW AUGER DHILL BIT COMPL 24 1885. WATER ELEV. FIRST LOGGED BY CHECKED BY IFROM TYPE OF PERFORATION FROM . T. Terry SIZE AND TYPE OF PACK NA FROM 10 195 FT TYPE OF SEAL AA Grout GHAPHIC LUG DESCRIPTION ķ (Drill Rate, Full lose, Odor, etc Clay, little to some sand, moist, stiff to very stiff, dark yellowish brown, light yellowish brown, pale brown (CL) 1533 10YR 3/4, 10YR6/4, 10 YR 6/3 .202 6 6 6 9 10-7. <del>7 3000</del> 10 2525 weathered claystone, moist, very stiff to hard, grayish 12 Lewisite Indication 12brown, layered (CH) 13

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A22-95

89 MC 114 A

PROJECT NO.\_\_

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	DESCRIPTION	Lithology	Plezomeler Installation	Çent.	Piezonel Dets Type Na.	Prosts Parist Balst	Corin Rate, Fluid loss, Od
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است رمر	aystone, moist, hard to	4	, ,		Ŧ	27 37	73000
	ery nara, gray is in proving					50/5	
	laystone, moist, hard to ery hard, gray ish brown, yered (CH) 2,5485/2	A	1		1 1		314
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A22-96

HOLE NO. M1-10 Woodward-Clyde Consultants PROJECT NAME RMA COE BORING LOCATION -90 Western DRILLING EQUIPMENT UNDIST. DHILL BIT DIST. Hollow Auger FIRST 24 HRS. WATER FROM 10 LOGGED BY 70 T. Terry FROM TYPE OF SEAL FROM 10 20 -rout GRAPHIC LOG DEPTH (FEET) REMARKS 2 5 8 E 5 E 5 DESCRIPTION (Drill Rate, Fluid loss, Odor, etc.) Fillay, little sand, gravel in 10ft, sample, moist to very moist, very dark gray to dark brown, 104R3/1, 104R3/2,104R3/3 6 72 8 10 3 767 6 5 8 8 12 9 10 3 767 12 17 Claystone, moist to very moist, firm to hard, weathered in top I foot 13

PROJECT NO. 89MC114A

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Historical States and

PROJECT NO. 89 MC114A

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SHEET ZOFZ

HOLE NO. M/-/ Woodward-Clyde Consultants PROJECT NAME \_ RMA BORING LOCATION Western UNDIST. DRILL BIT Auger 24 IIRS. FIRST CHECKED BY LOGGED BY FROM T. Terry FROM 10 SIZE AND TYPE OF PACK 10 19 FROM TYPE OF SEAL 0 Grout DEPTH GEET) Waler Conten DESCRIPTION (Drill Rate, Fluid loss, Odor, etc.) Fill, clay, sandy moist to very moist, very dark grayish brown to dark gray 10 YR 3/2, 10 YR 3/1 230 45 5 clay, sandy, calcureous, dry to moist, stiff to very stiff, yellowish brown 5 8 57 9 104R5/4, 2.545/4 10 24,4 8 14 Claystone, trace silt, trace to little sand, firm to very hard dark olive gray, blueish 5 Y 3 / Z

PROJECT NO. 89MC114A

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odward-Clyde	DESCRIPTION			Lithology	Plezomeler Installeria	200		Recor. 11	5-	REMA	RICS
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J	LOCATION Sec   .							ATUM		
HILLIN	IG AGENCY Layne Western DHILLER	R.	McKe	ay	DATE	FHI	41ED 3HED		2-90	• • •
HILLIN	IG EQUIPMENT CME 75			/			MH DEL		SAMI'LEN T. Tel	rry
HILLIN	IG WETHOU Hollow Auger DHILL B	IT.				IO. O			COMPL 24 I	1413
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YPE O	F PERFORATION NA FROM		10	F L		GCU .	_		CILCULUS SI	•••
	NO TYPE OF PACK NA FROM .		10	27	7.	7	erry			
TPE O	F SEAL Grout FHOM	<u> </u>	1º204,	5		٠		A1184 E C		•
	DESCRIPTION .		CHAPT	Plores		Ontant	Para Ke	1	REMARKS.	
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. ‡	clay, sandy, moist, stiff.  to very stiff, brown,  dark grayish brown,	ŀ			- 1		Ŧ .	11.		٠.
+	dark yellowish brown.		/			- 1	Ŧ-	-		
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<b>' T</b>	104R4/4, 104R5/4		/	$2^{n}$			1:3	6	1 '''	
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Ŧ	weathered Claystone, very stiff, moist to dry, yellowish brown, light olive brown	1				1.	1-1	10		
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+	brown, light olive brown						‡	1.	1 .	
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PROJECT NO.

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DESCRIPTION	Lithology	Plezometer Installation	Woter Content	Type Ma	Perent fi	Corth	ROID, Fluid	ks Jose, Odor, PM
Claystone, hard to very hand, dry to moist; olive brown (CH), 2.5 44/4					36 44		24	
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HOLE NO. M1-13 Woodward-Clyde Consultants PROJECT NAME RMA Western DHILL BI ontinuous CORE 24 11/13. COMPL WATER . LOGGED BY T. Terry FROM SIZE AND TYPE OF PACK 10 20 Grout Lithology DESCRIPTION Fill, Clay, gravelly, brown 104R6/4 Sludge, light gray, layered white, black, wet, 104R7/1 12.6 16.1 Clay, light yellowish brown, wet, 1048 6/4 (CL) Weathered Claystone, blocky, dark yellowish brown (CH) 21.9 10-10YR4/4 71 -12-13-

A22-103

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SHEET\_

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PROJECT NO

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Woodward-Clyde Consultants PROJECT NAME RMA BURING LOCATION DRILLING AGENCY Western Layne COMPLETION DEPTH DRILL BIT Cont. Core WATER . SIZE AND TYPE OF CASH LOGGED BY HUH TYPE OF PERFORATION SIZE AND TYPE OF PACK T. Terry NA FROM O TYPE OF SEAL Grout (Dritt Rate, Fluid loss, Oder, etc.) DESCRIPTION Fill, Gravel, clay, moist, brown; 10YR4/3 Sludge, moist, gray, white black, 2727 PPM Lewisite! Indication . 30 PPM Lewisite Clay, moist, sandy, gravelly, Indication. light brownish gray, (CL) 10YR6/2 5798 PPM 419 PPM 10 weathered Claystone, moist to dry, calcareous, blocky, fractured; (CH); 10YR3/3

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Woodward-Clyde Consultants PROJECT NAME RMA COE HOLE NO. AD.    CLUATION AND ADULT	DINCE LOCATION Sec.   DINCLE MALLER MALATHER CONTROL TO THE PROPERTY TO THE PR	MUUMITII CIVAA OO:	Remarks Am 1	WOOLG:	***************************************					_			NO. M	
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yellowish brown, moist 10 YR3/4  Sludge, wet, gray, black, white, red  Clay, wettomoist, brown  Clay, wettomoist, brown  Weathered claystone, wet to moist, brown, highly fractured, blocky	yellowish brown, moist 10 YR3/4  Sludge, wet, gray, black, white, red  Clay, wettomoist, brown  Weathered claystone, wet to moist, brown, highly fractured, blocky	D)	ESCRIPTION	•	Lithology		meter	Sale of the sale o	Z Z	Acces.	Series (Series (n)	•-		r, e
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Woodward-Clyde Consultants PROJECT NAME RMA DURING LOCATION Sec URILLING AGENCY Western Layne SAMPLEH T COMPLETION DEPTH HO. OF DISL DRILL BIT Cont. Core FIRST COMPL 24 1985. WATER . SIZE AND TYPE OF CASING NA CHECKED BY LOGGED UY FHOM FHUM . T. Terry SIZE AND TYPE OF PACK NA FHOM 10 TYPE OF SEAL 0 Grout REMARKS. \*0 DESCRIPTION (Drill Rate, Full loss, Odor, etc.) ř. hald letion Roadbase, Gravel Sandy, brown, dry very dark gray Clay, very moist, brown, stiff stiff 3 Sludge, gray, very moist, 611 PPM Sand, clayey, moist verydense Rig Refusal 9 10

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Moodward-Clyde Consulta	nts WP PROJECT	NAME _K		COE	HOLE: NO/Y]
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Woodward-Clyde Consultants PROJECT NAME RMA DONING LOCATION DHELER M. Walker Western COMPLETION DEPTH 10 Cont. Core 24 IIII 3. SIZE AND TYPE OF CASHIG NA LOGGED BY FROM 10 fillu . T. Terry SIZE AND TYPE OF PACE NA 10 10 FHOM TYPE OF SEAL GHAPHIC LOG (Drill Rate, Full loss, Odor, etc. DESCRIPTION Clay, dry to moist, stiff, dark yellowish brown, 10YR4/4 (CL) 3 Clay, very sandy, moist to very moist, brown 10485/3, (CL) 3.49 PPM 0 SHEET\_\_\_OF 89 MC114 A

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DO IECT NO

Woodward-Clyde Consultants PROJECT NAME BMA HOLE NO. M/-19. UORING LOCATION 90 DRILLING AGENCY Western avne COMPLETION DEPTIL HUDIST. DIST NO. OF DRILL BIT Core 24 HRS. COMPL WATCH ELEV. CHECKED BY LOGGED BY FROM TYPE OF PERFORATION NA FHOM . SIZE AND TYPE OF PACK 10 15 4FHQM GroutGHAPPIC LOC DESCRIPTION (Drill Rate, Fuld toes, Odor, etc.) Clay, moist, sandy, soft to stiff 3 Sand, silty, clayey, wet, 947 PPM: loose, brown Clay, sandy, moist to wet, calcareous (aeolian), stiff to very stiff, brown palebrown 2054 PPM 10. Lewisite Indication  $\mathcal{H}$ Sund, silty, wet, trace chy, mediumdense, brown 12.

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ward-Clyde Consultants To PROJECT NAM	I Holony	GHAPHIC LOG Lithology Pletometer						REMARKS	
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Woodward-Clydo Consultants PROJECT NAME \_ RMA DORING LOCATION DHILLEH M. URILLING AGENCY Western DATE FRIISHER Layne COMPLETION DEPTH DUITTING EQUIPMENT 750 DHILL BIT Core FIRST 24 IMS. SIZE AND TYPE OF CASING NA LOGGED OY FHOM TYPE OF PEHPOHATION FHULL T. Terry SIZE AND TYPE OF PACK 10 10 FROM TYPE OF SEAL Grout 70 Chie (Ortif Rate, Full loss, Odor, etc.) DESCRIPTION Fill, clay, gravelly, moist, stiff, dark, yellowish brom 10YR4/4 Sludge, sangray, soft, white, brown, moist 6 Clay, sandy, stiff, moist yellowish brown 10 YR5/4 9 189 PPM 10 89 MC114A

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Woodward-Clyde Consultants	PROJECT	NAME _	K	MA	<u>C(</u>	<u> </u>		HOLE	NO. 7	
BORING LOCATION Sec /				ELEVATION AND DATUM						
UNILLING AGENCY Layne Western	DHILLEN	Walk	er	DATE SI			7-	27-90	<u> </u>	
DHILLING EQUIPMENT CME 750				COMPLE	THOH C	Ertil	10	SAUPLER 7	. Terry	
DHELING METHOD Cont. Core	DHILL BIT			MO.	65	m51.		Unoist.	15.000	
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TYPE OF PENFORATION NA	FROM	10	FL	LOGGEO				CHECKED BY	· · · ·	
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HILLING METHOD	Cont.	_	04166 811			MI). SAMPL	.esi	DISL	11 6	COUPL	24 1813.
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<b>_</b>		<del>90 114</del> 8					-				OF : [

Woodward Clydo Consultants PROJECT NAME RMA COE BORING LOCATION Western COMPLETION DEPTH UNDIST. Core Cont. COMPL NA CHECKED FROM TYPE OF PERFORATION NA 10 FROM T. Terry SIZE AND TYPE OF NA FROM O TYPE OF SEAL DESCRIPTION (Drill Rate, Full loss, Odor, etc.) FilG-ravel, clayey, moist, light yellowish brown, 104R614 (GC) Fill, Clay, moist, sandy, brown 10YR4/3 (CL) Sludge, gray , black, white, blocky, moist, soft Clay, dark brown, moist 10YR3/3 (CL) 10 Core Samples G-Geosafe A-Armylab

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Woodward-Clyde Consultants De PROJECT NAME \_ BUILTING LOCATION DRILLING AGENCY Western CME DUILL BIT Core COMIL FRIST SIZE AND TYPE OF CASING NA LOGGED BY TYPE OF PERFORATION T. Terry SIZE AND TYPE OF PACK 10/0 TYPE OF SEAL Grout GHAPPIC LOC DESCRIPTION (Drill Rate, Full lose, Oder, etc.) Fill, Gravel, clay, moist, dark brown, 104R3/3 Sludge, gray, white, black, 3 Clay, sandy, moist, stiff, yellowish brown, (CL) 10 YR 5/6 130 PPM 10 CORE Samples G-Geosafe A-Army T-Geotech

A22-118

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Woodward-Clydo Consultants PROJECT NAME RMA COE BURING LUCATION 24-90. Western COMPLETION DEPTH UHUIST. Core Cont. WATER . LOGGED BY NA T. Terry NA FHOM DESCRIPTION (Delli Rate, Field loss, Oder, etc.) Fill, Gravel, clayey, sandy, moist, brown, 104R4/3 Sludge, gray, brown, white dry to moist 292 PPM Clay, little to trace sand, moist, dark gray, 10YR4/1 5798 PPM 10 CORE Samples G - Geosafe A-Army

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Sludge, moist, gray, white, black  Clay, sandy, brown, moist  104R5/3  767 PPM Lewisite Indication	05	DE	SCRIPTION	• . •	Lithology		etion *	i i	1	1 2 2 2	(Octil Rate, F	luld loss, Oder, et
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Clay, sandy, brown, moist 104R5/3  767 PPM Lewisite Indication	<u> </u>		. •					-	-			
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Woodward-Clydo Consultants PROJECT NAME RMA COE BUTTING LOCATION 26-90. DRILLING AGENCY Western COMPLETION DEPTH DIST. DHILL BIT Cont. Core 24 11113. COMILE WATER . FIRST SIZE AND TYPE OF CASING NA CHECKED BY LOGGED BY FHUM TYPE OF PEHPORATION FRUM . 10 SIZE AND TYPE OF PACK NA T. Terry TYPE OF SEAL Grout GHAITHIC LOC 3.0 OLPIX GEET) Clase DESCRIPTION (Ortif flate, Falki loss, Odor, etc. Fill, grarel, clay, moist,. sandy, light, yellowish brown, 10 YR 6/4 Clay, sandy, calcareous, moist, dark grayish brown 10484/2 (CL) 8 9 10 Core Sumples 89MC114A OF\_ SHEET\_

A22-122

ממת זולרד אות

Woodward-Clydo Consultants PROJECT NAME RMA COE DORING LOCATION Walker UNILLING AGENCY Layne Western Cont. Core WATER . CHECKED DY FOCCED IIA FHOM 10 T. Terry SIZE AND TYPE OF PACK FHULL . NA FROM O TYPE OF SEAL (Drill Rate, Full toss, Odor, etc.) DESCRIPTION Fill, gravel, little clay, moist to wet 0,6 PPM clay, moist to wet, stiff, brown 104R4/3 Clay, sandy, wet, very-stiff, dark grayish brown 7,544/2 III PPM 10 samples G - Geosafe

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A22-123

SHEET\_\_\_\_OF\_

89MC114A

Coodward-Clyde Consultants PROJECT NAME R				EFEAUTION WIN DATON						
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PROJECT NO

A22-124

SHEET\_\_\_OF\_

Woodward-Clyde Consultants PROJECT NAME RMA . Sec. 25 Layne Western BOHING LOCATION DATE STARTED 0-90 R. McKay DRILLING AGENCY Layne Western DATE FMISHED COMPLETION DEPTH DRILLING EQUIPMENT 75 DIST DRILL DIT Hollow Auger FIUST 24 MRS. WATER . CHECKED OY FHOM LOGGED BY T. Terr FHUM . 10 SIZE AND TYPE OF PACK 10 TYPE OF SEAL 6 Grout GHAINIC LUG DESCRIPTION (Drill Rate, Fuld loss, Oder, etc.) Clay, moist to very moist, brown, (CH) 104R4/3

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PROJECT NO.

A22-125

OF.

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MOORW	ard-Clyde Consultant	B PROJECT	NAME	KME		OE		HOL	E NO. 25
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PROJECT NO.\_\_\_

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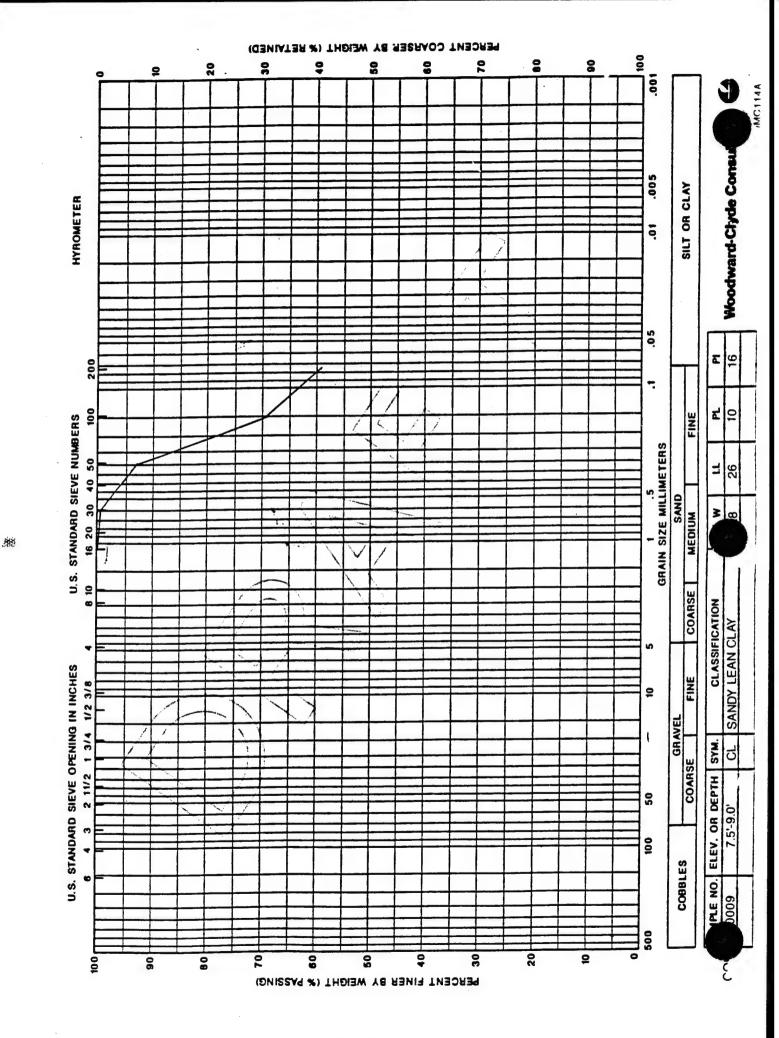
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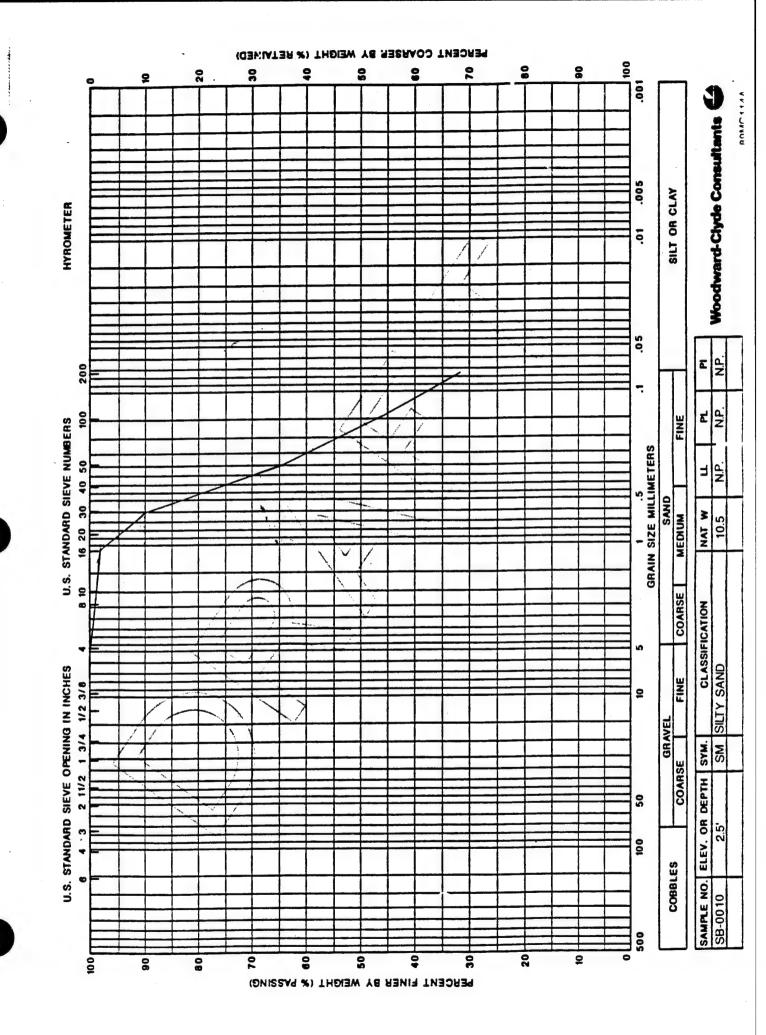
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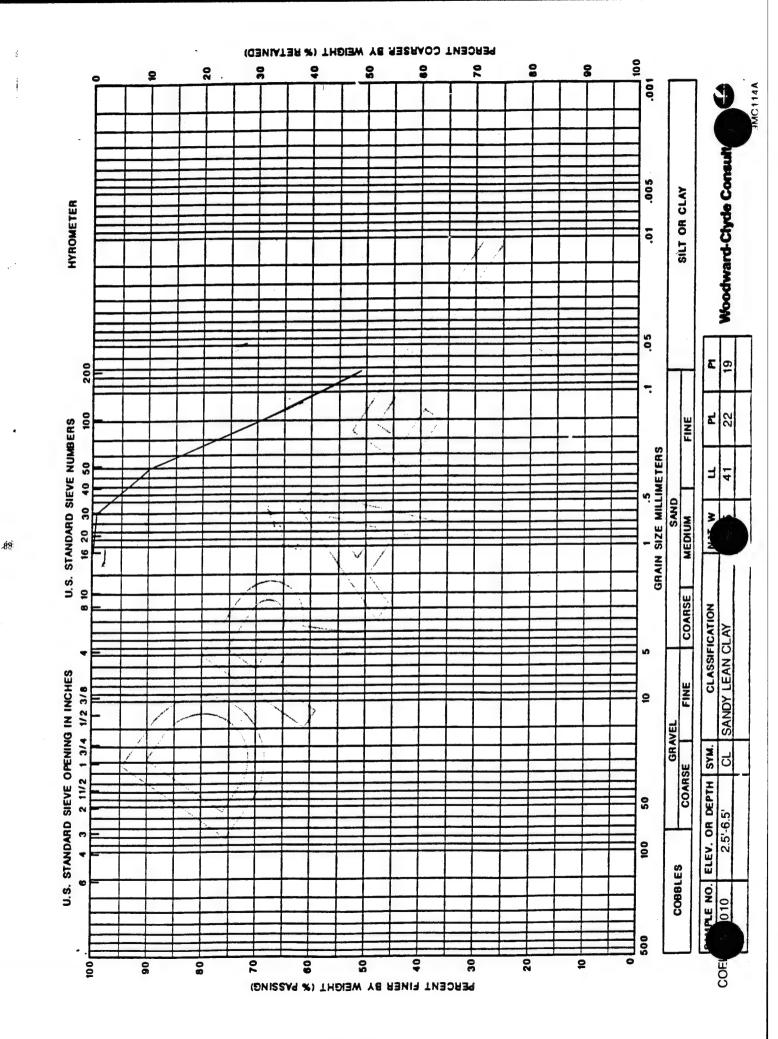
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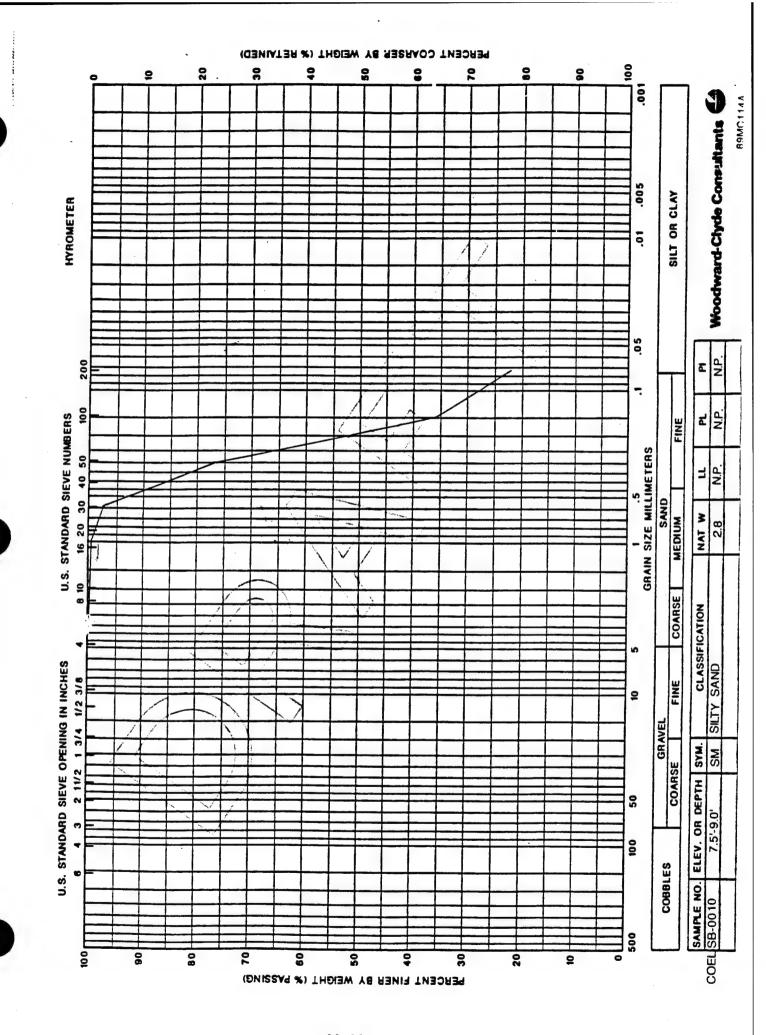


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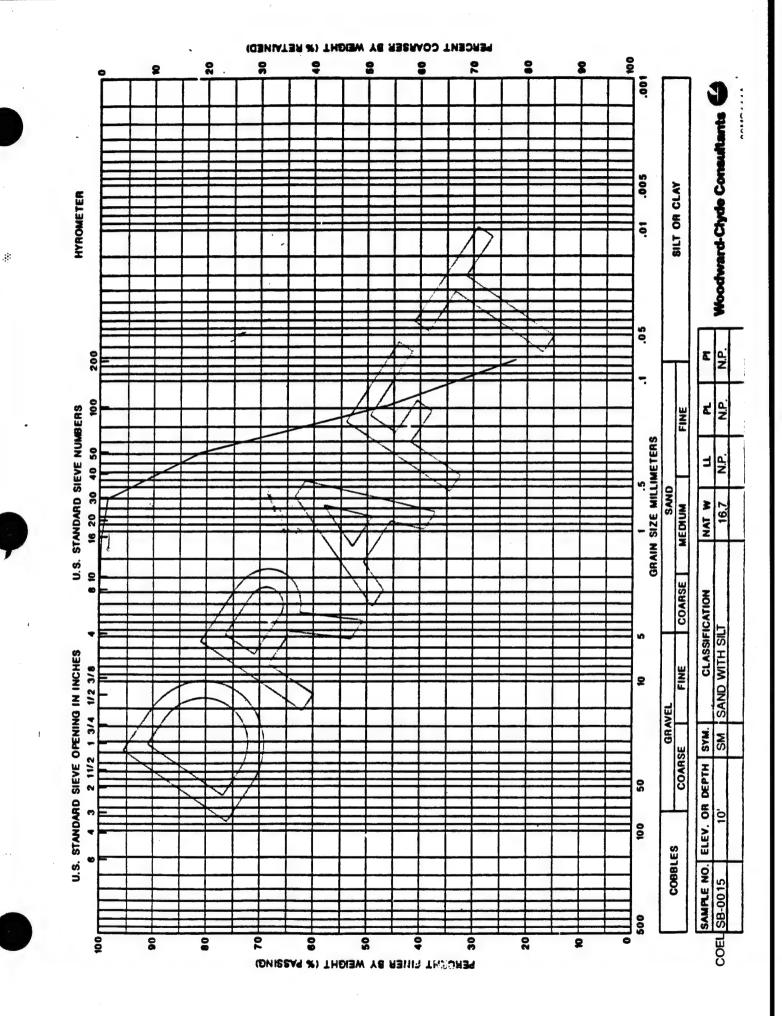
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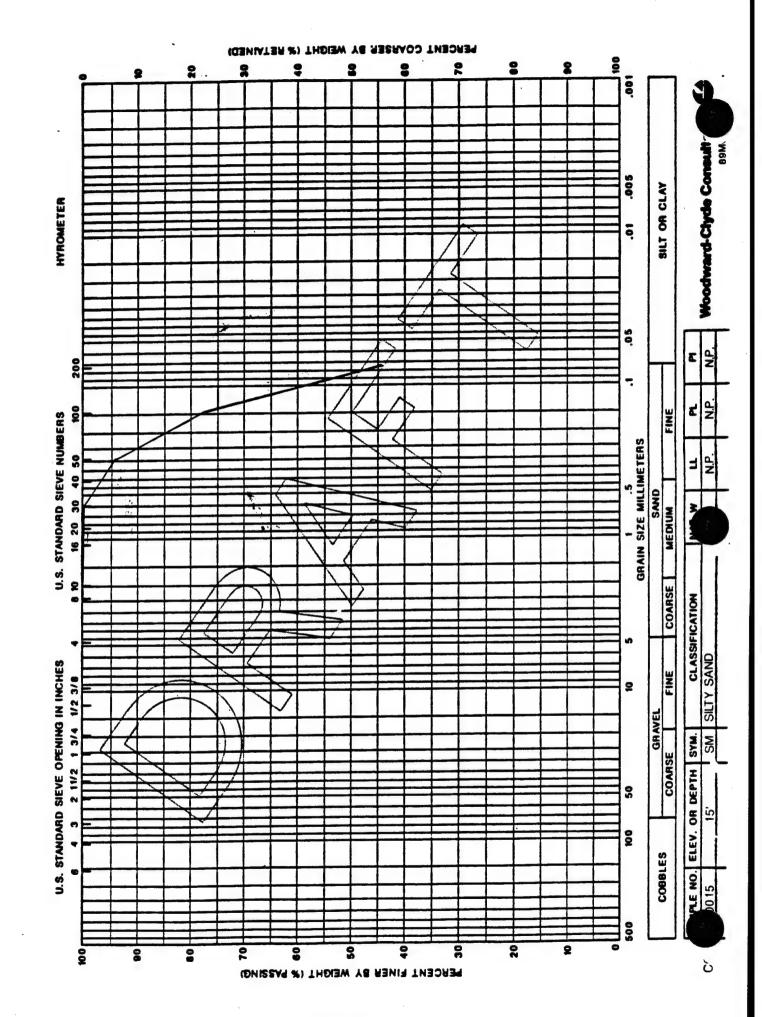
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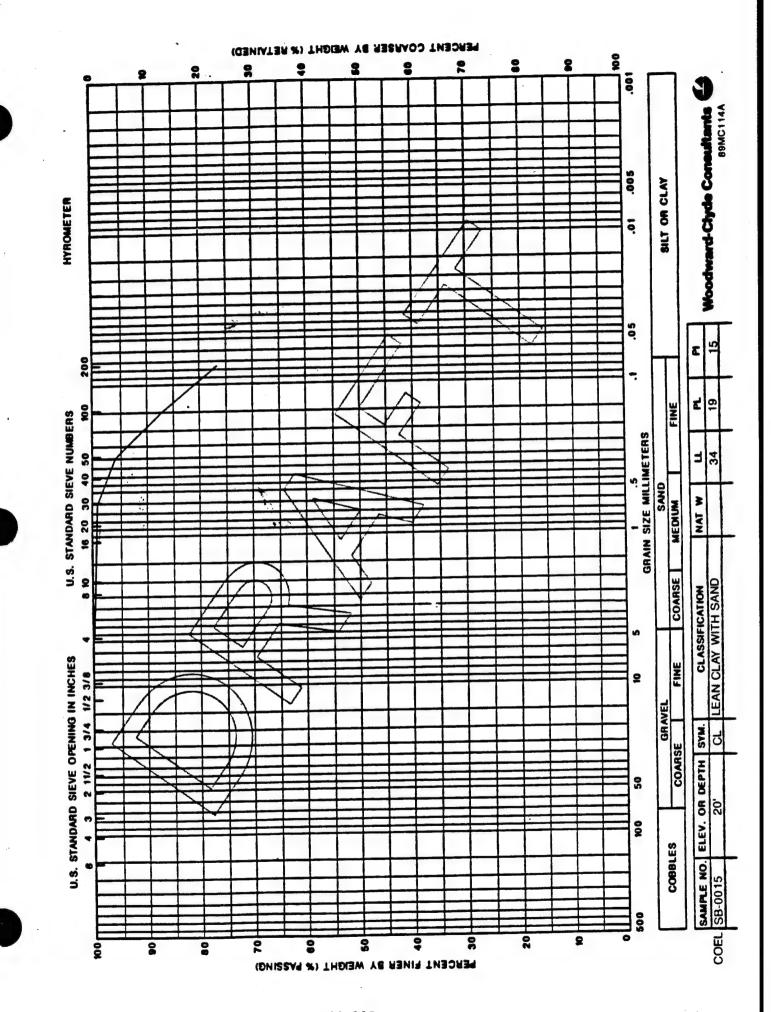
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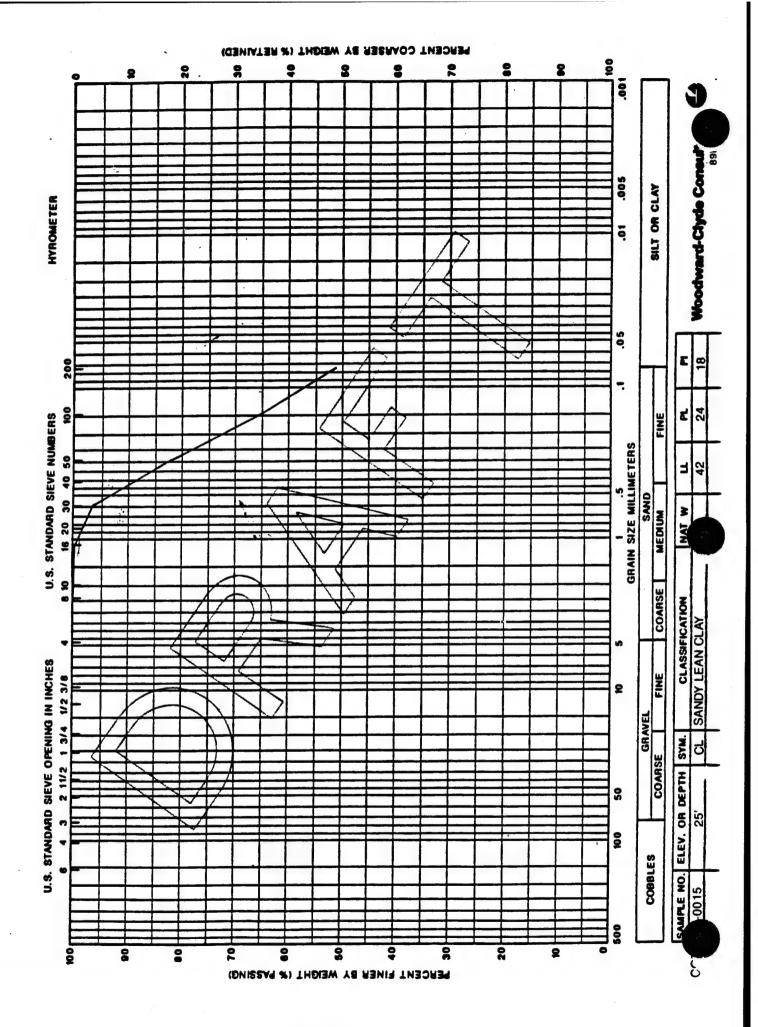
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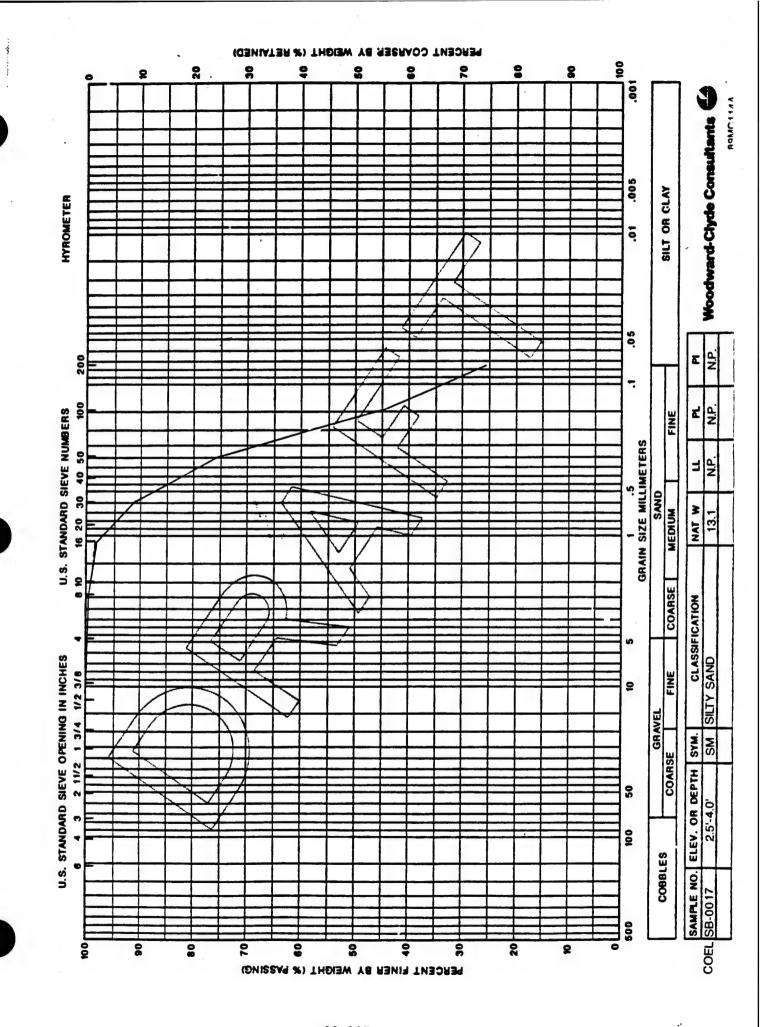


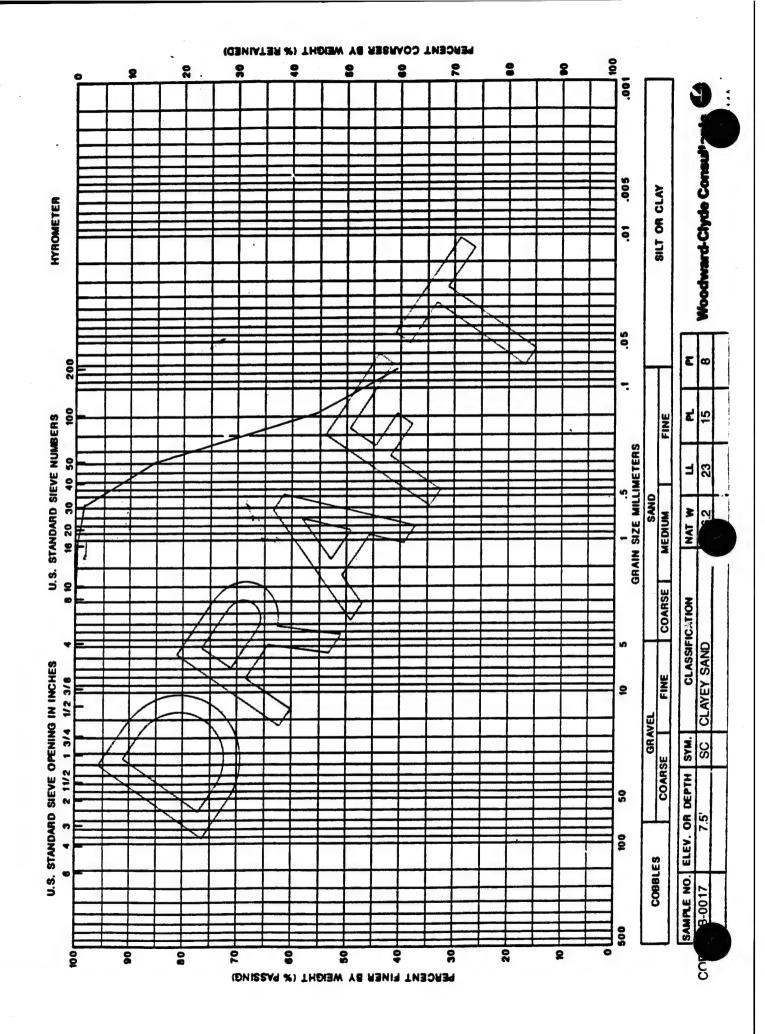


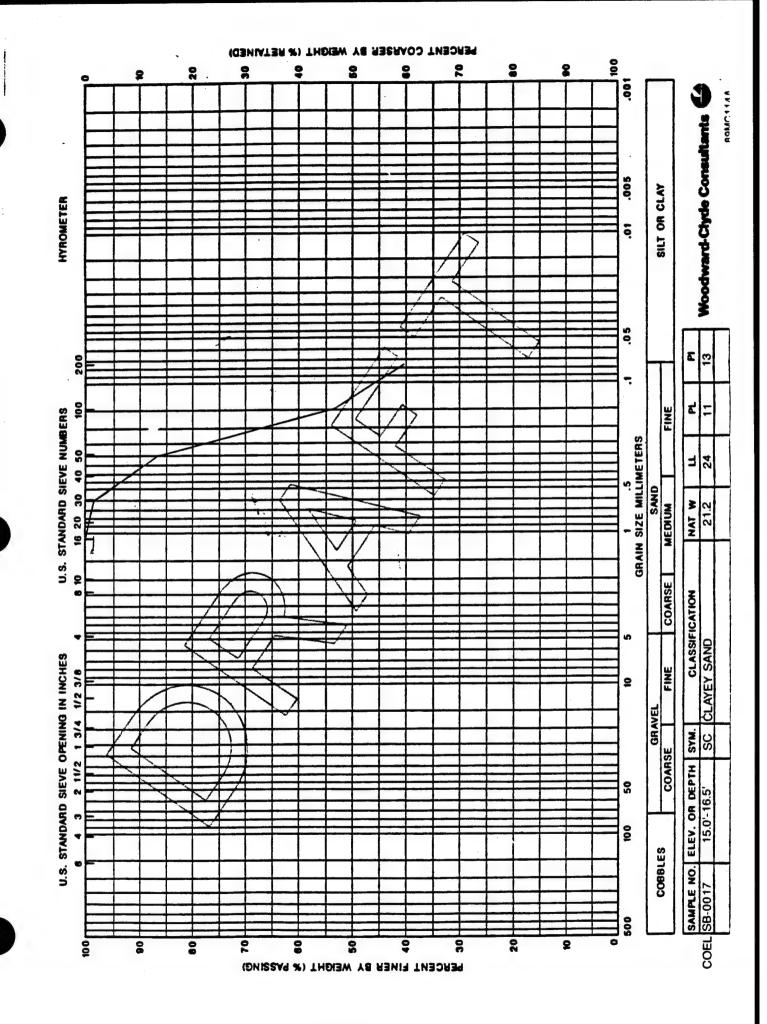


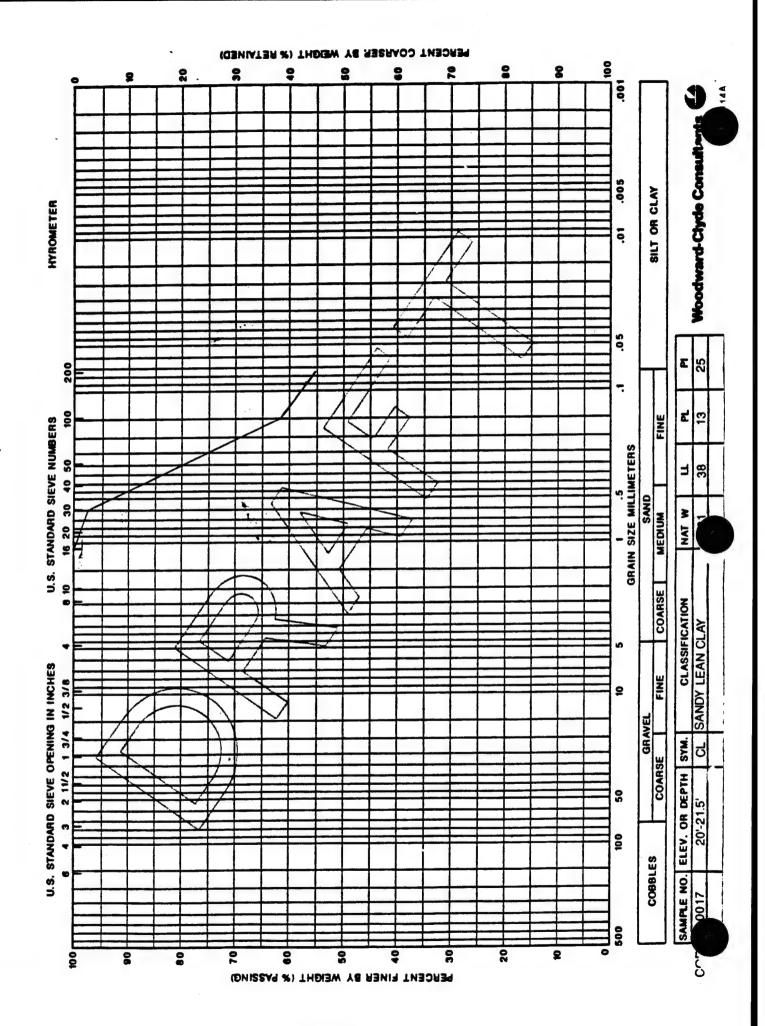


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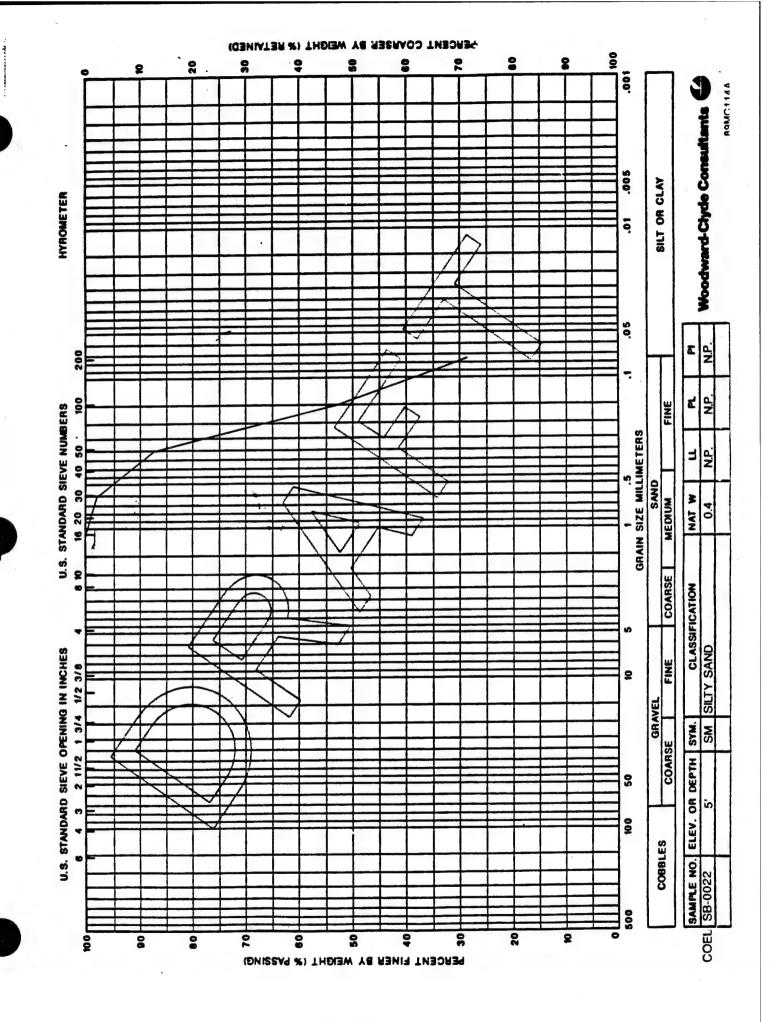


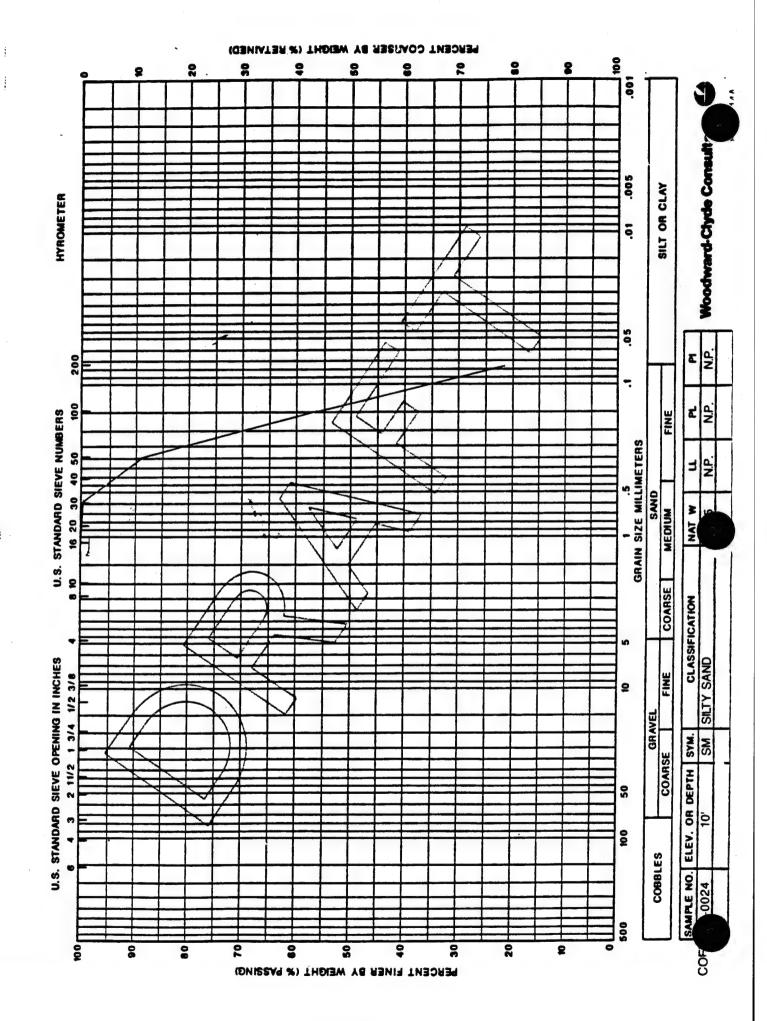




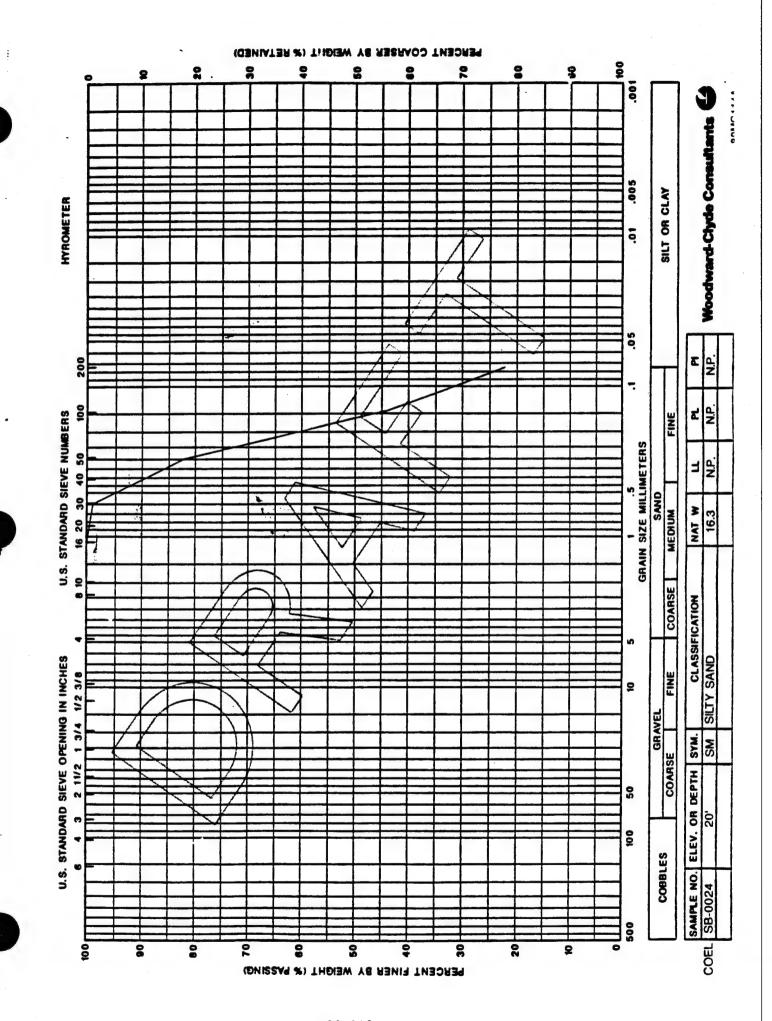


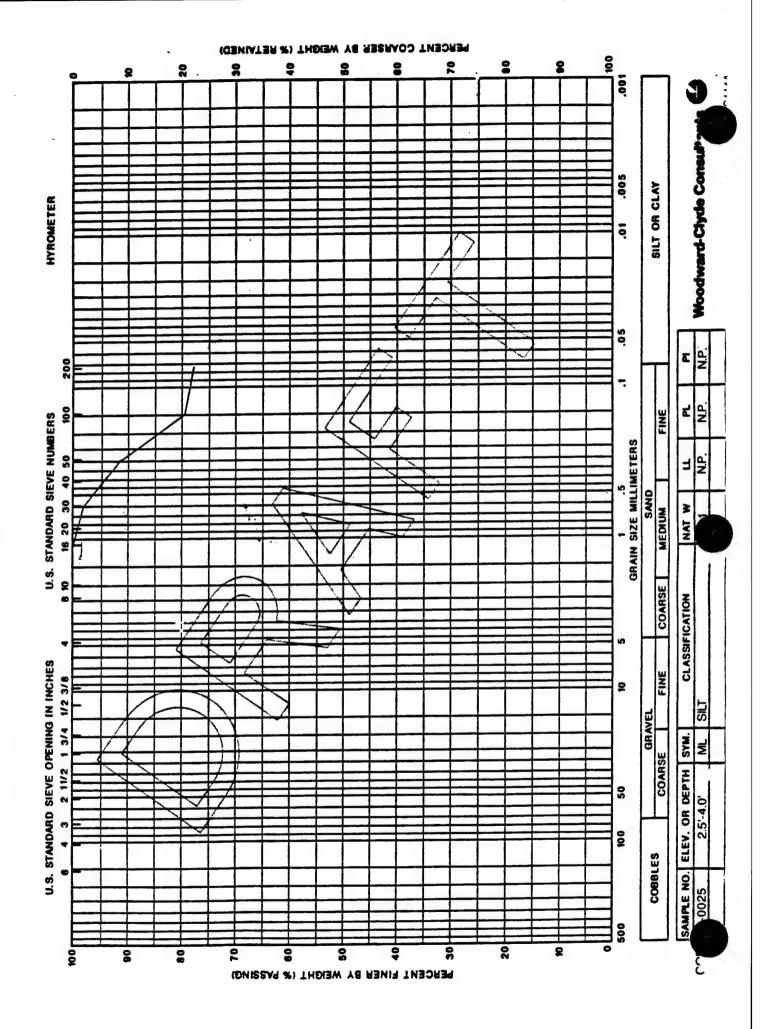
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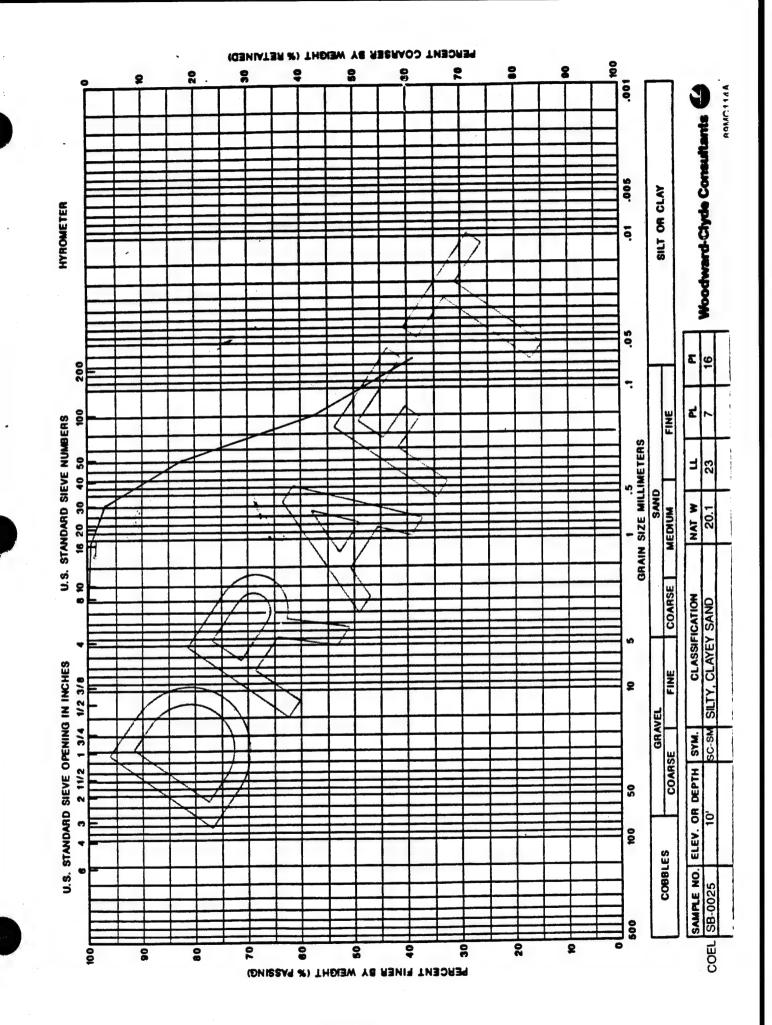


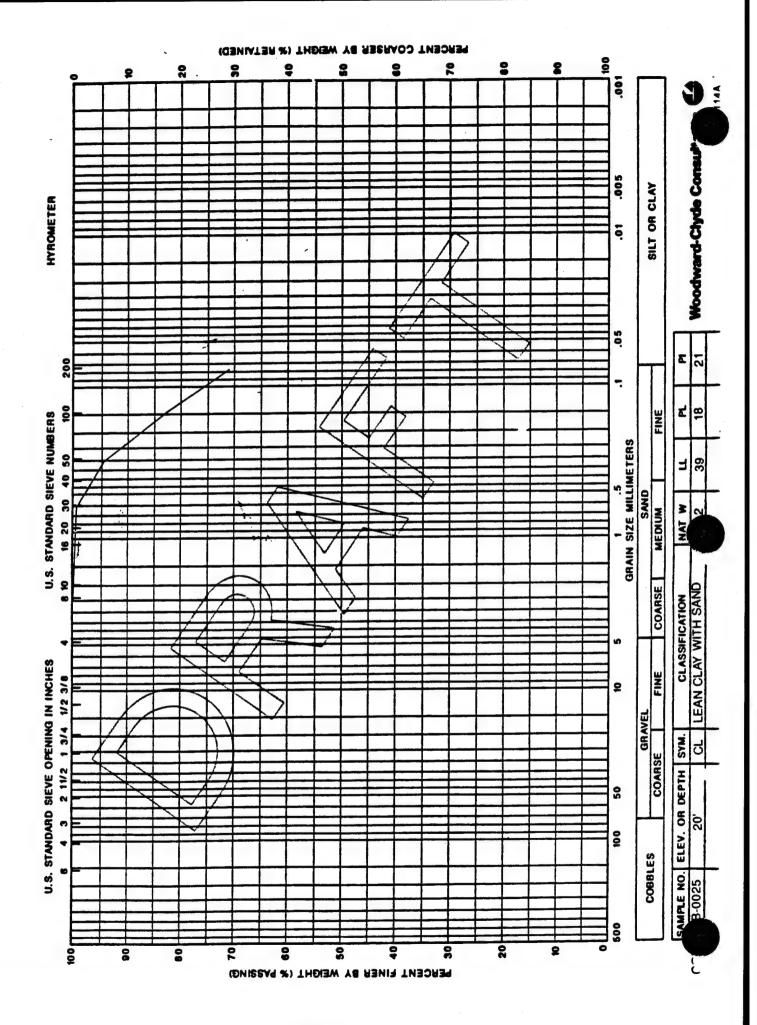


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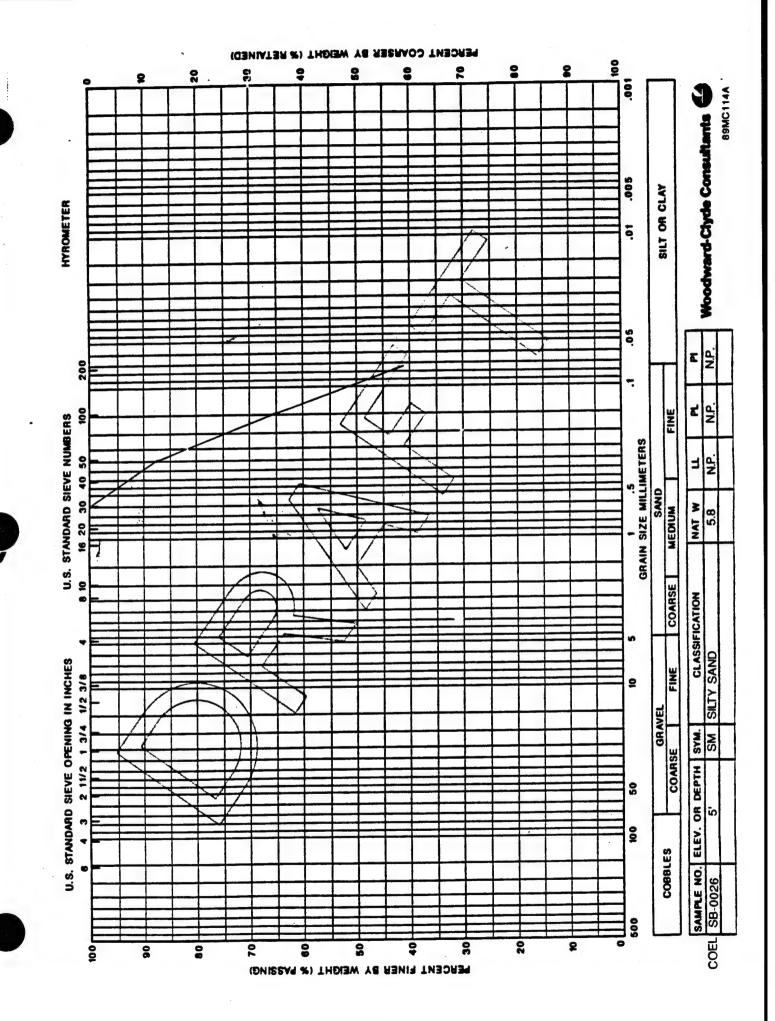


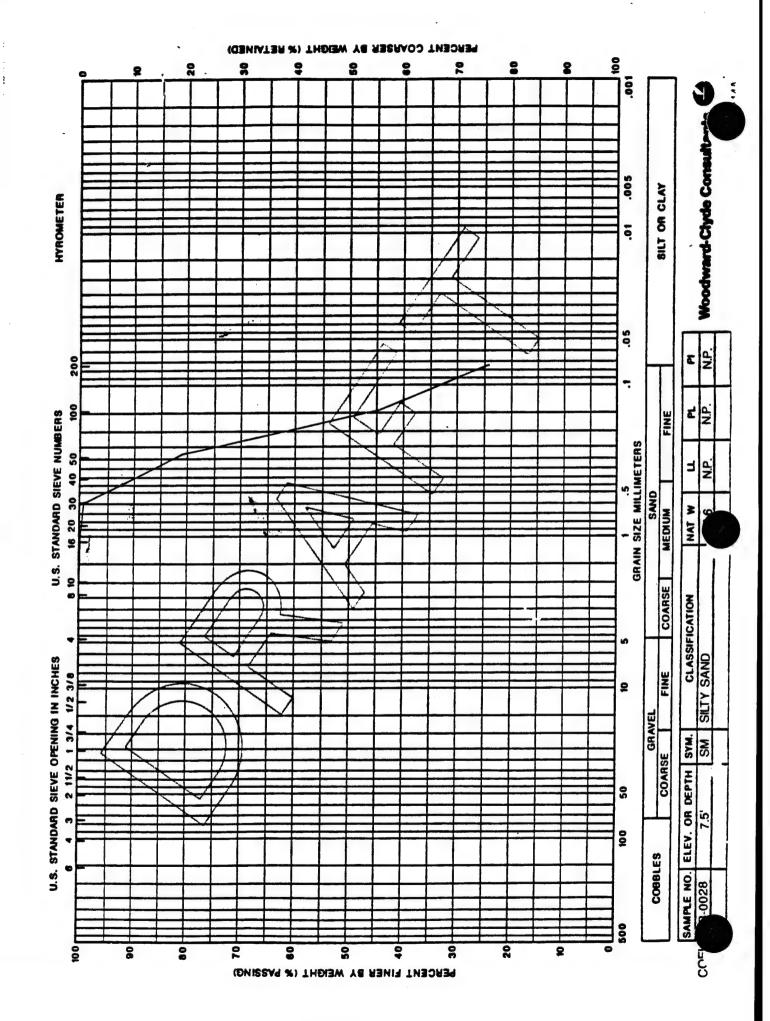


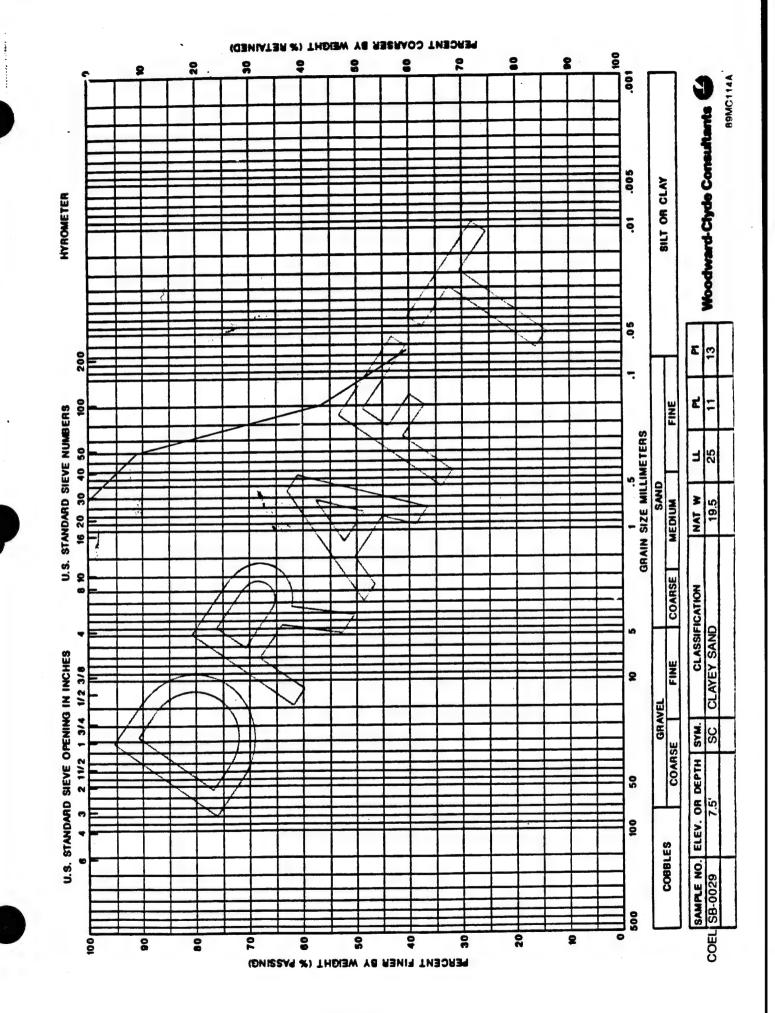


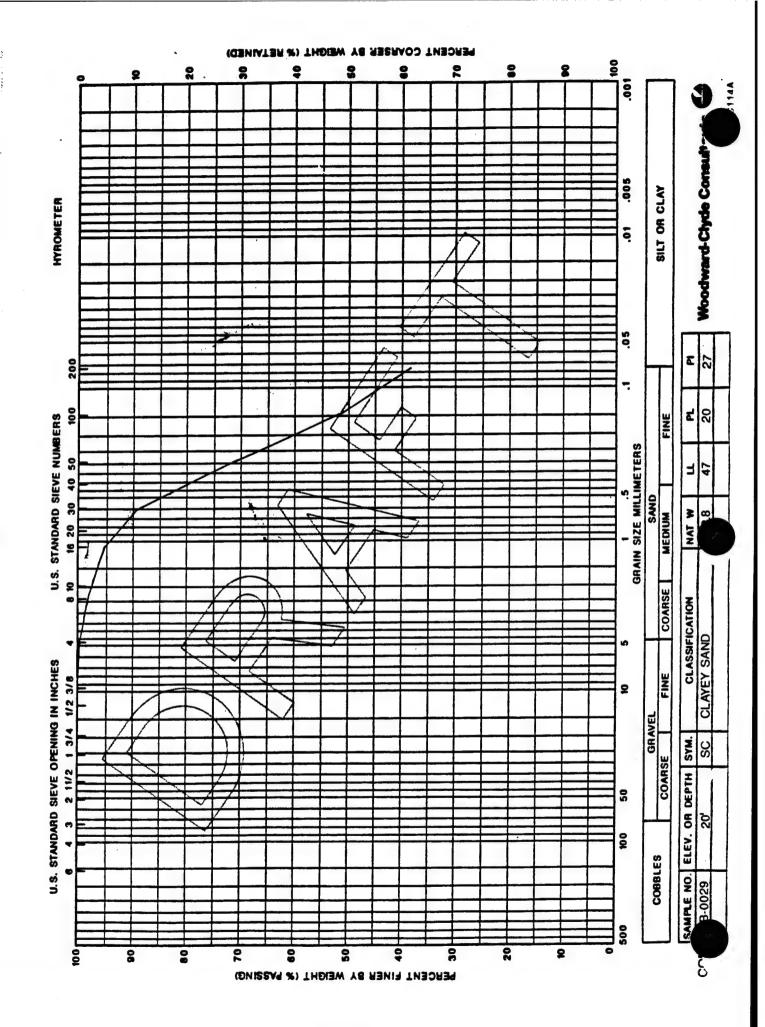


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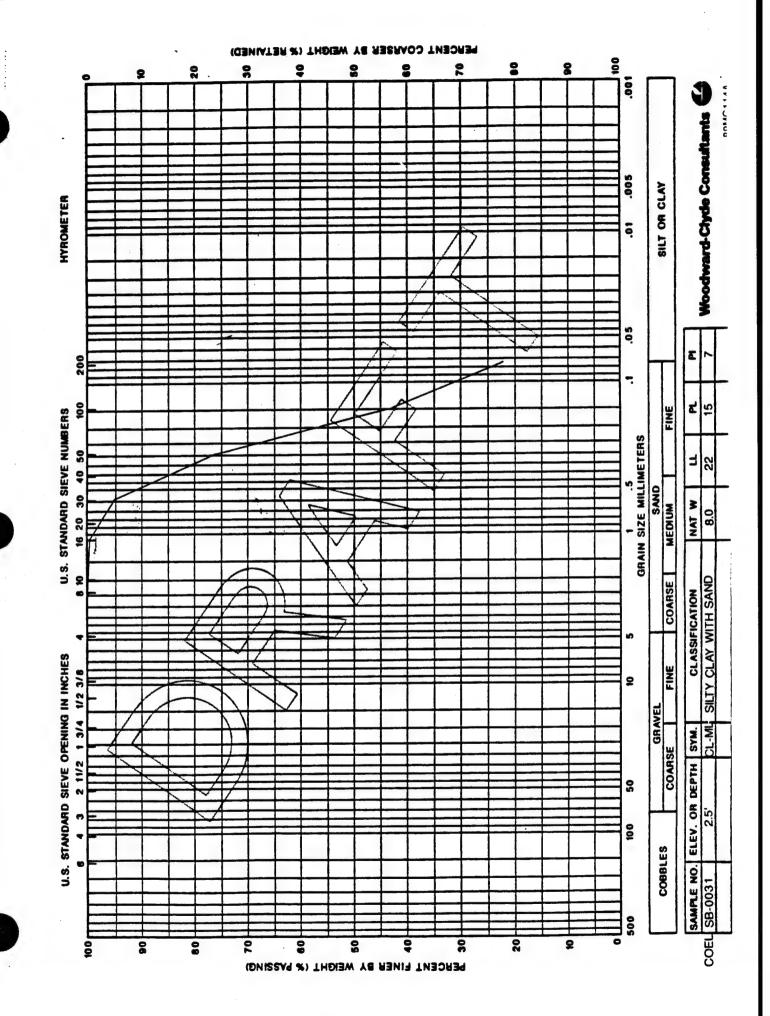


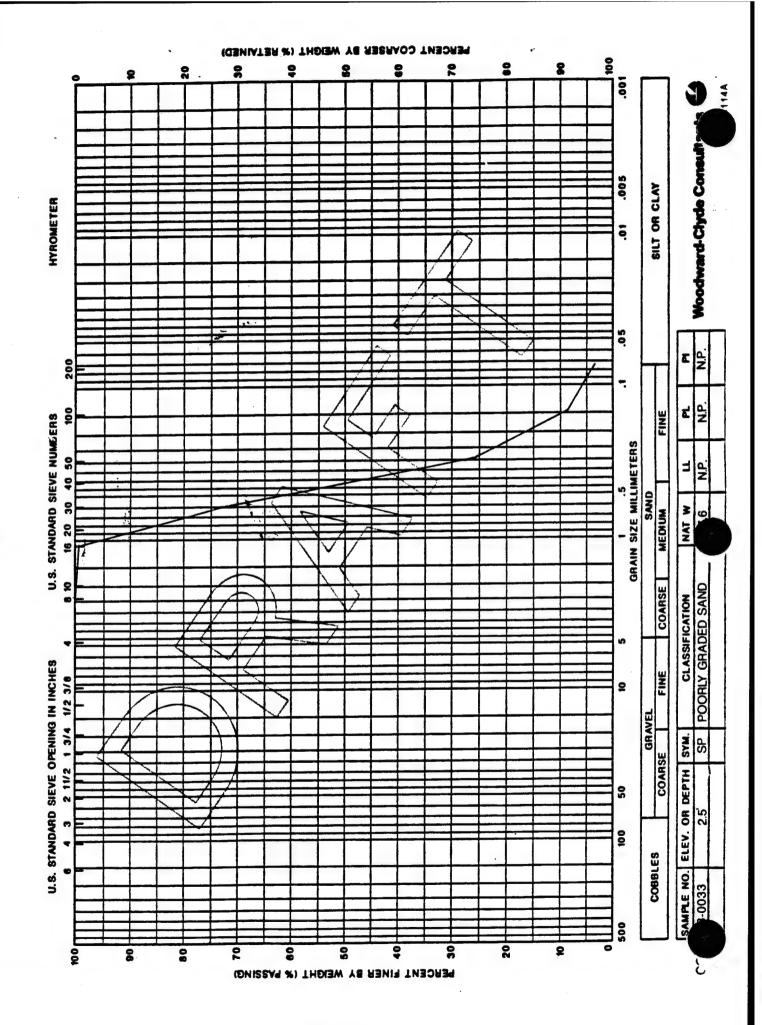




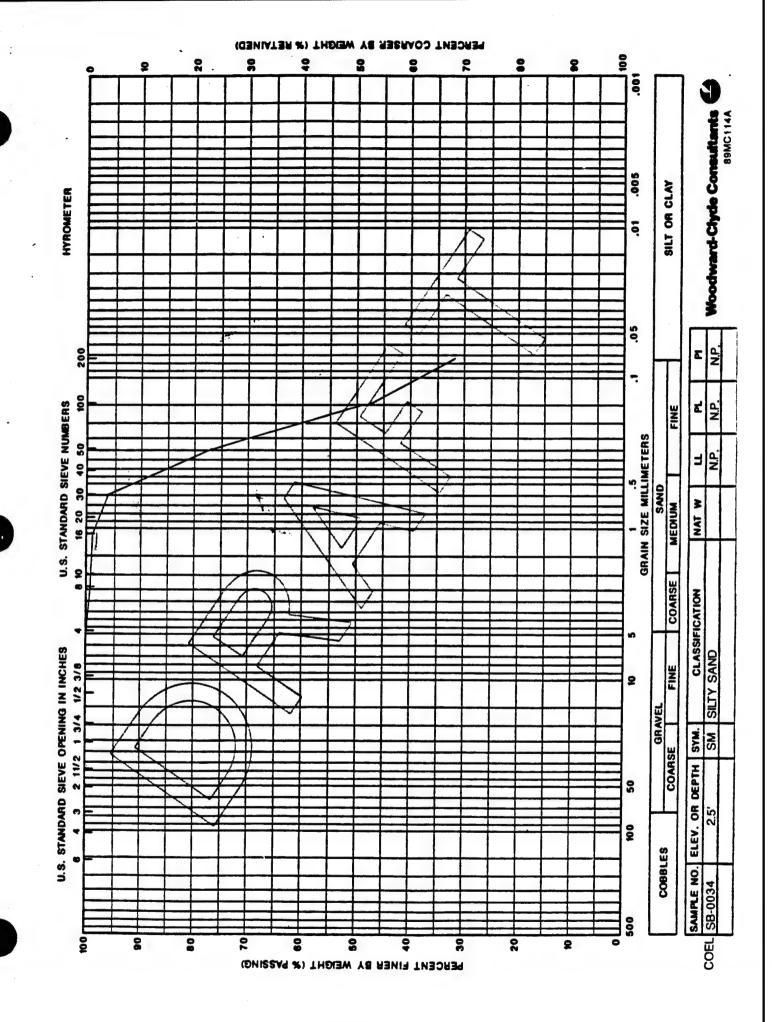


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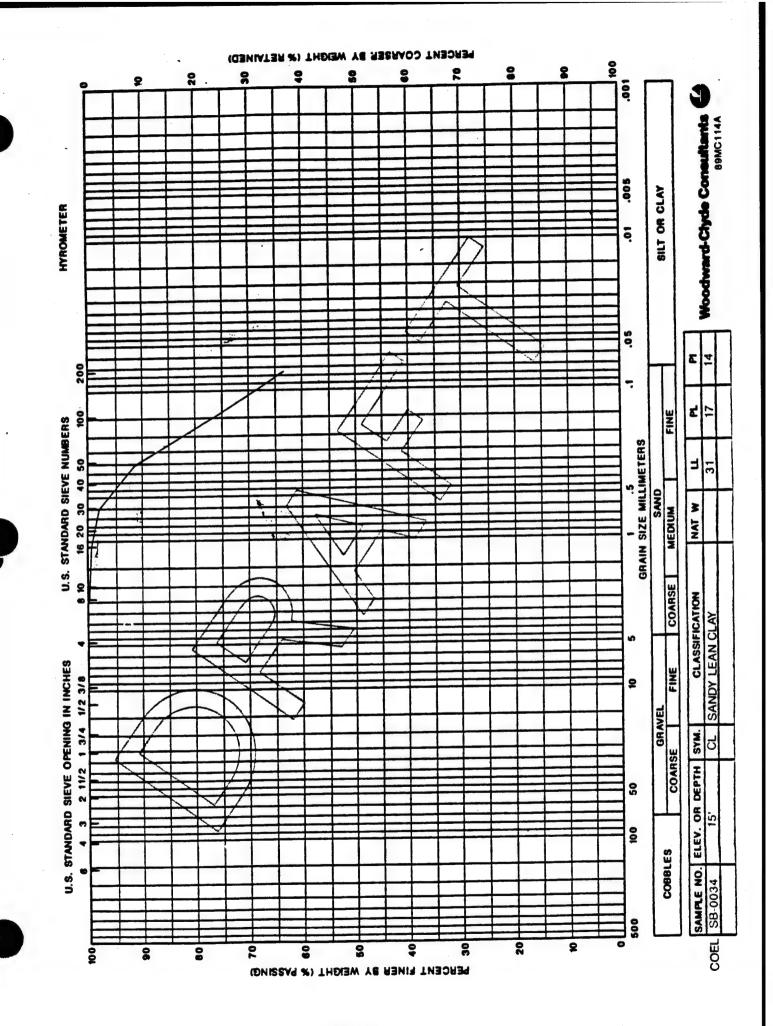


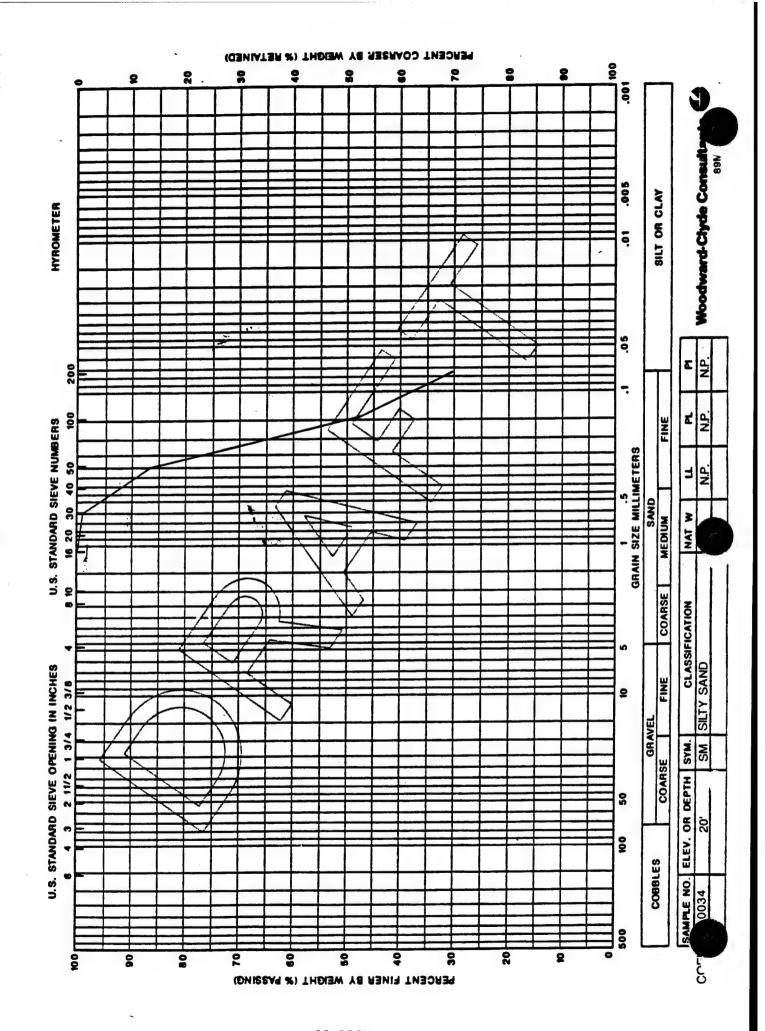
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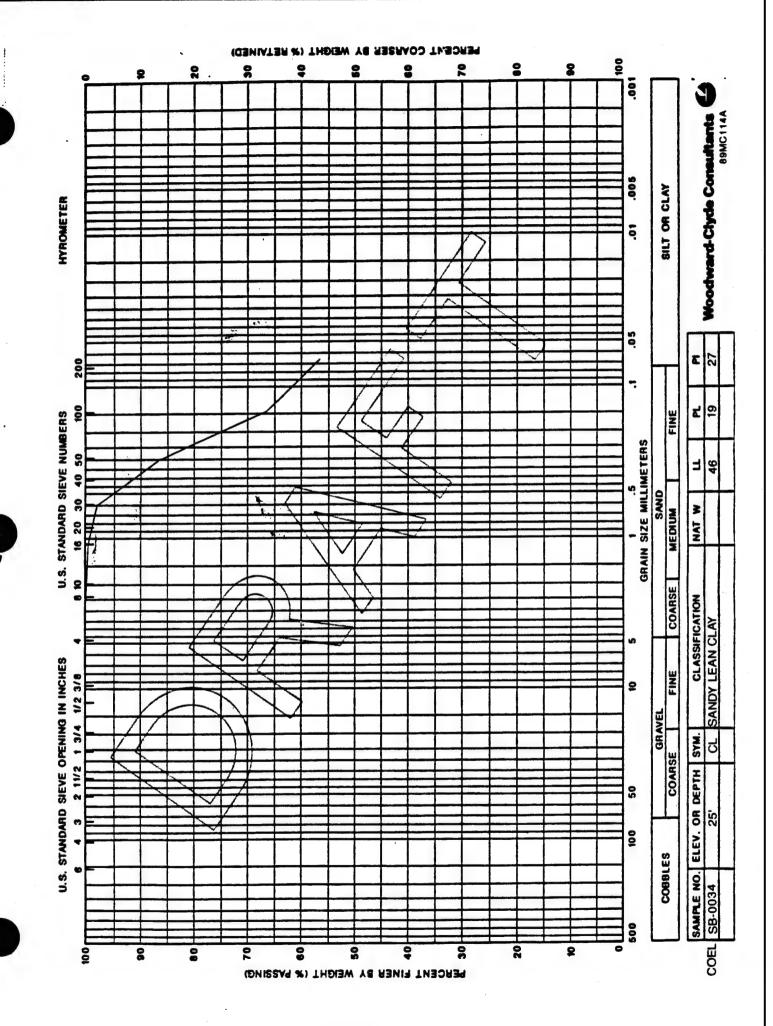


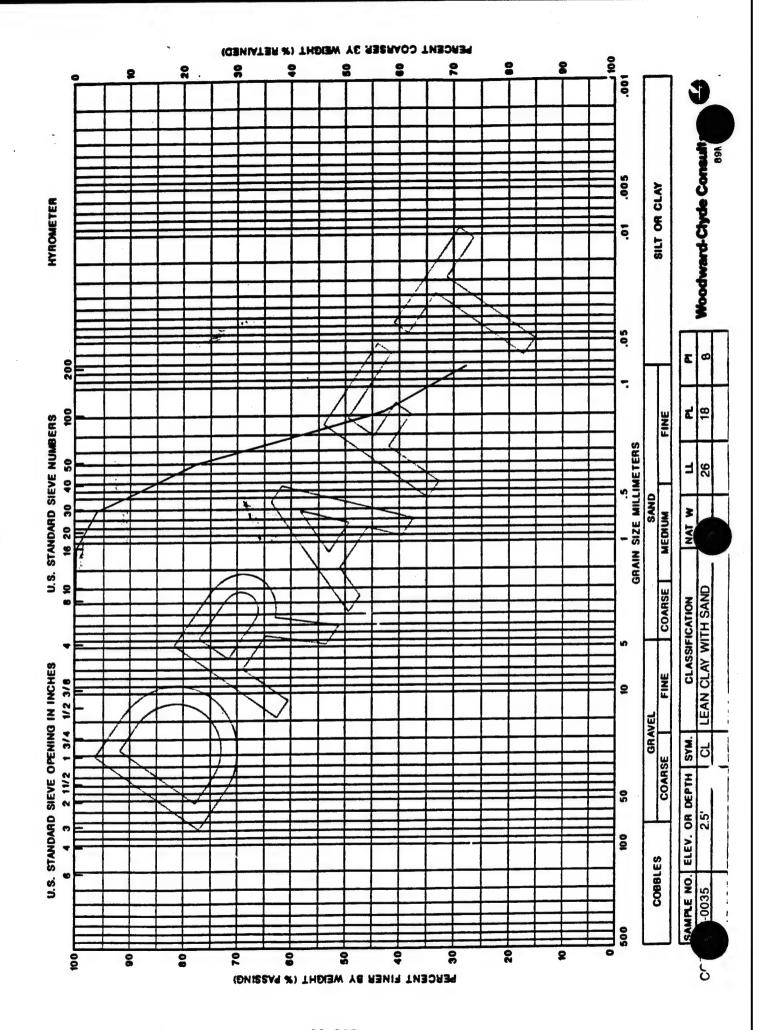
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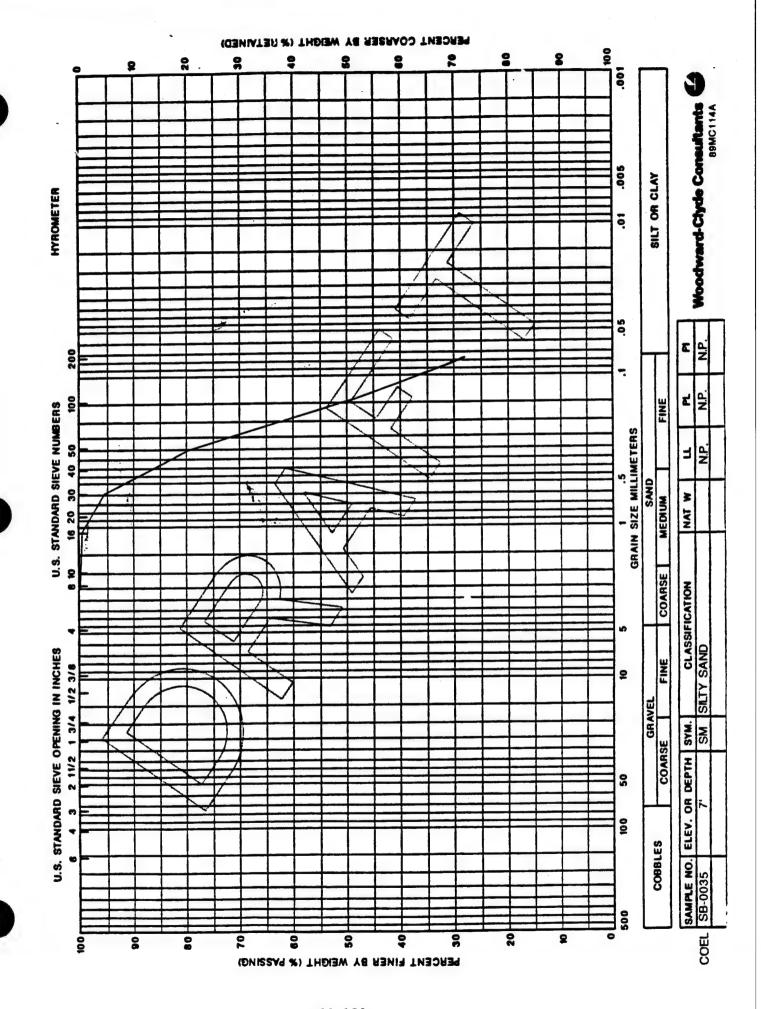


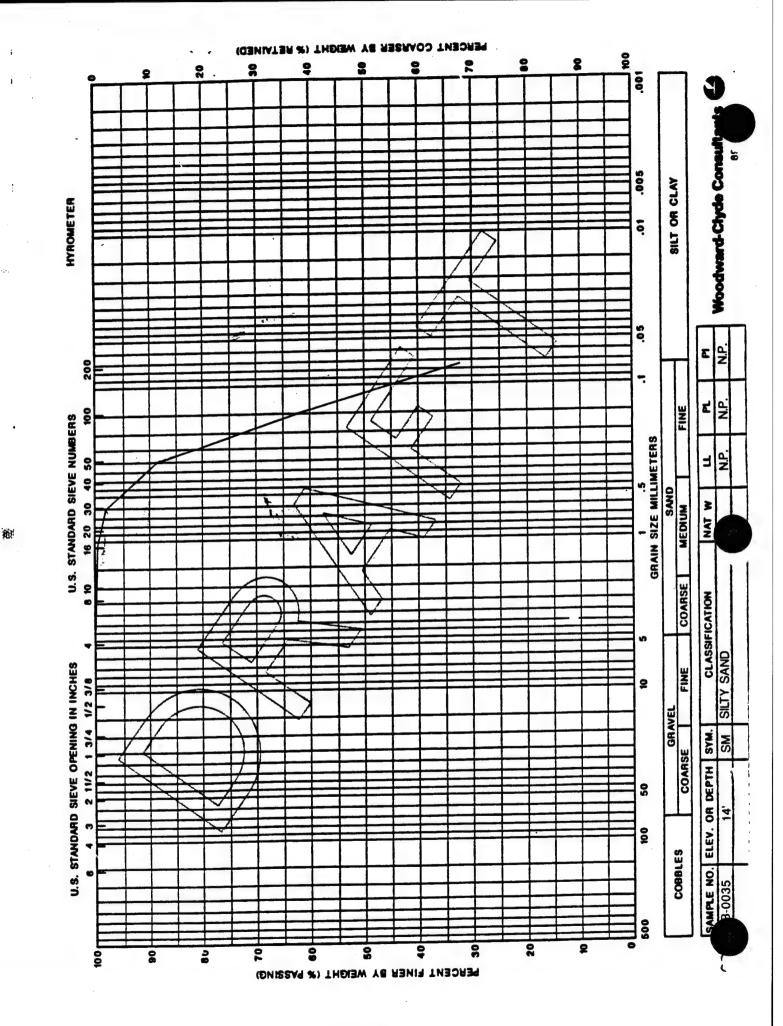




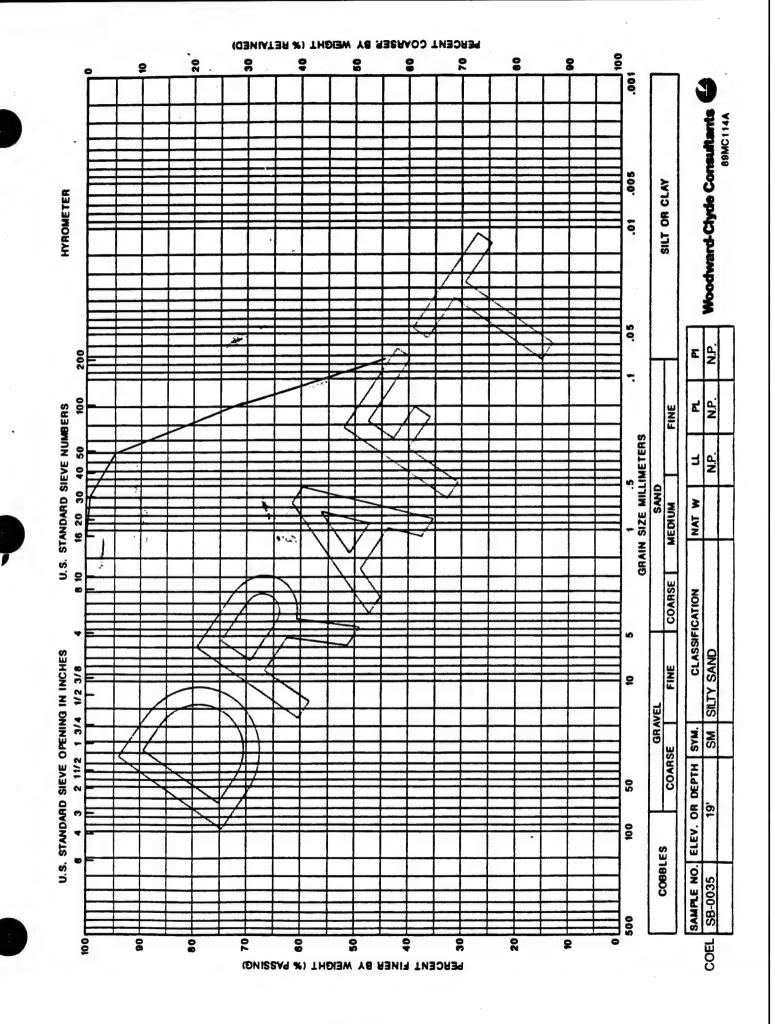


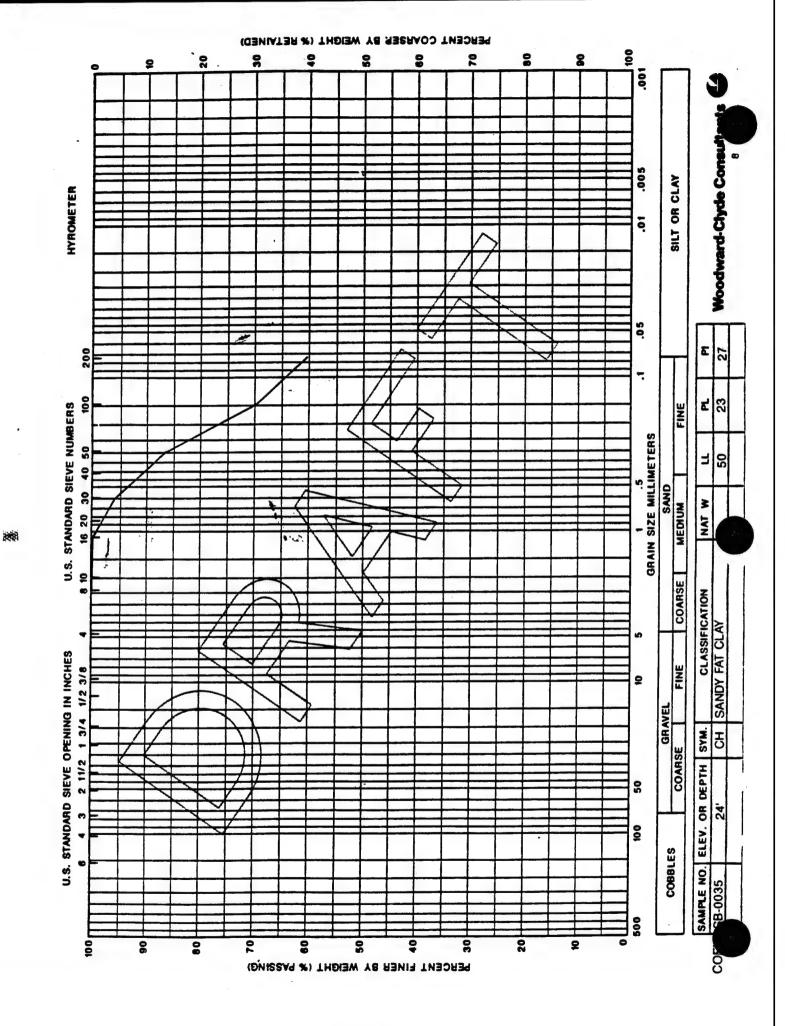
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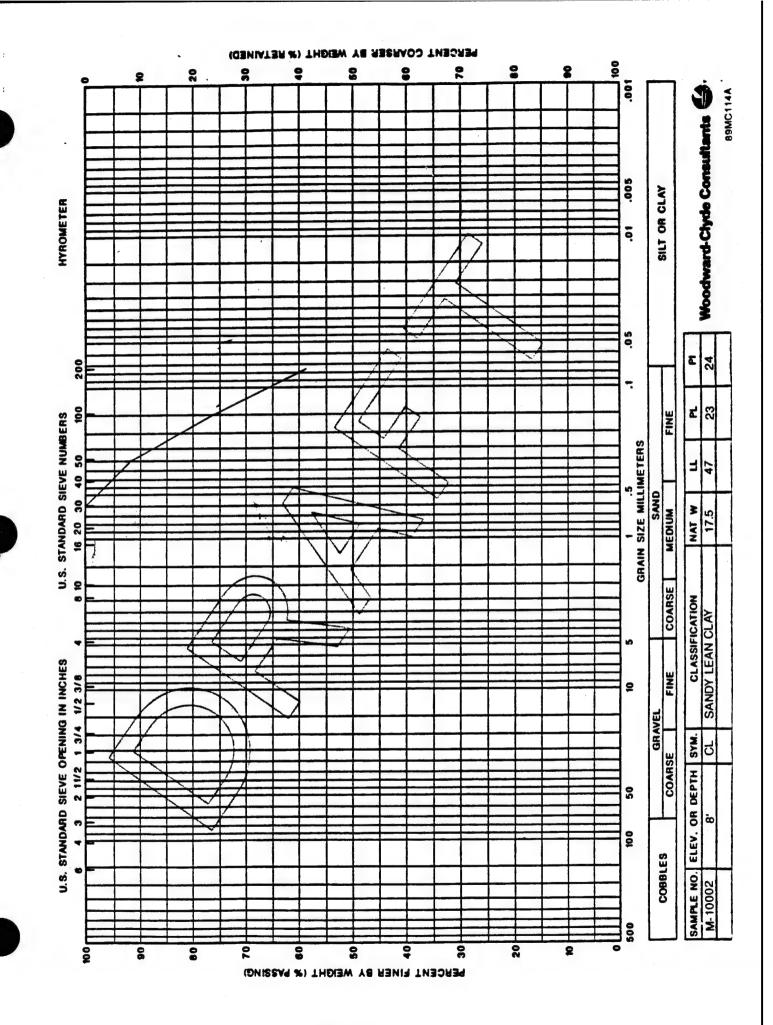


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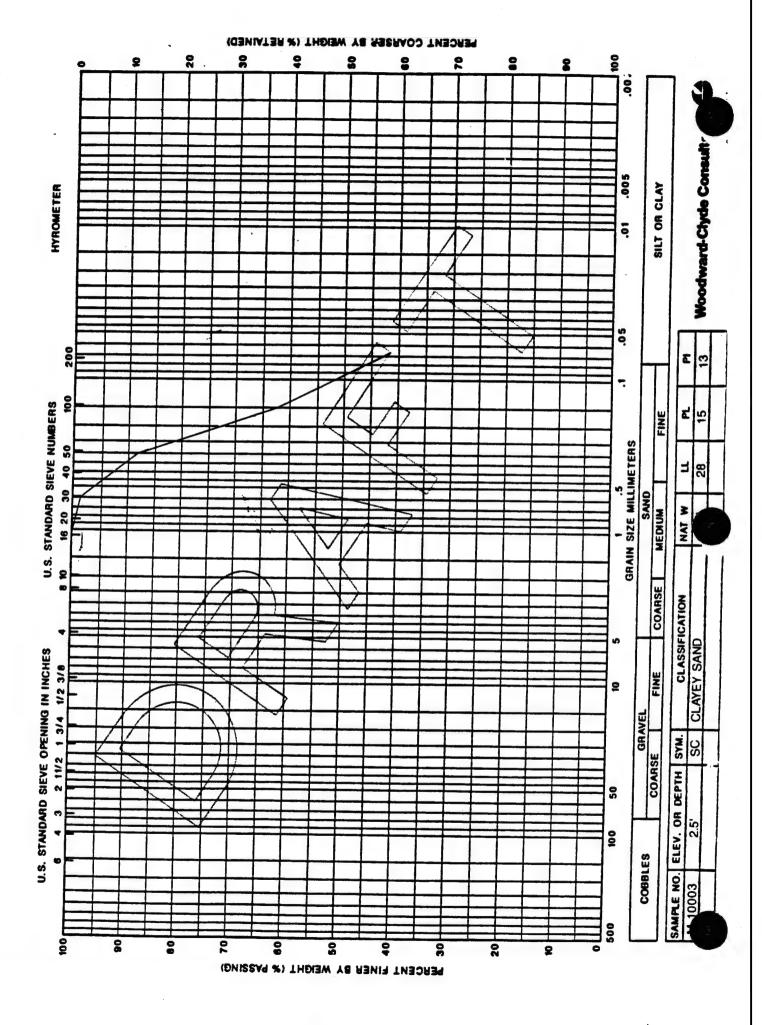


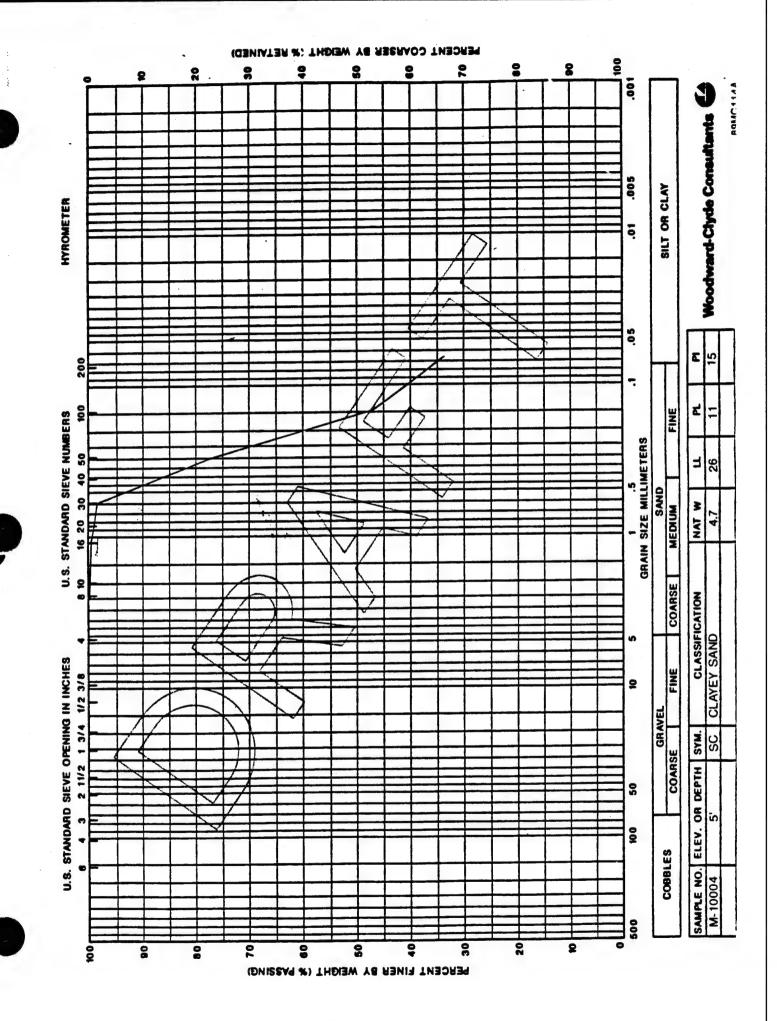


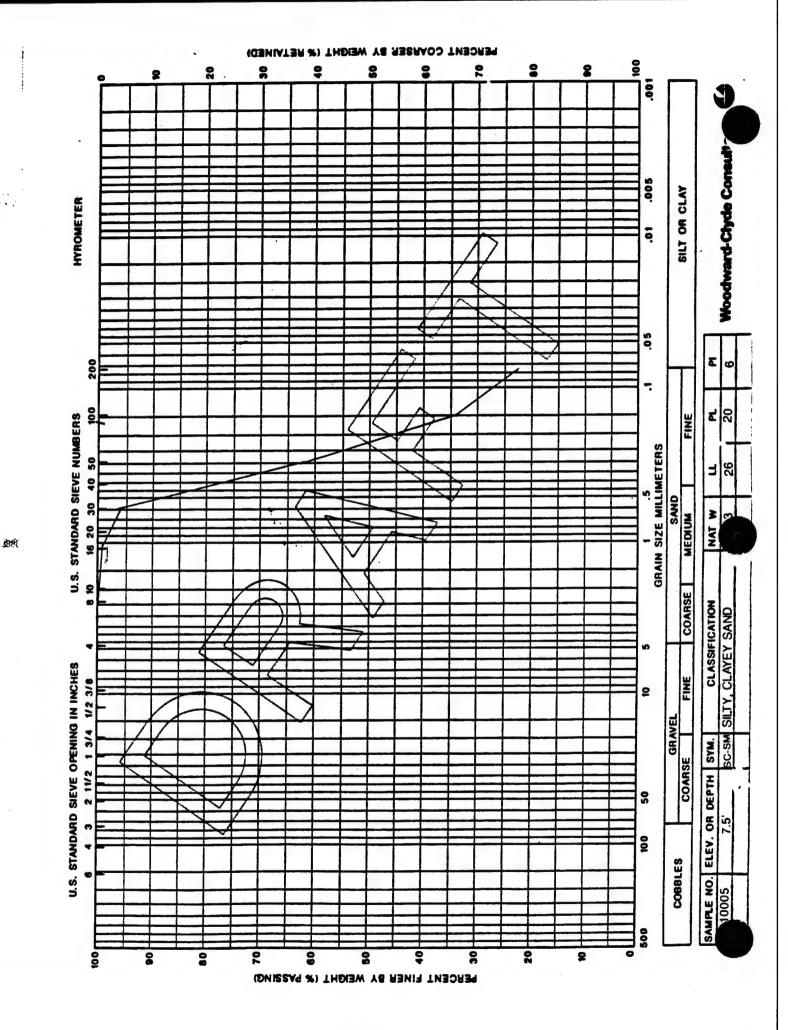
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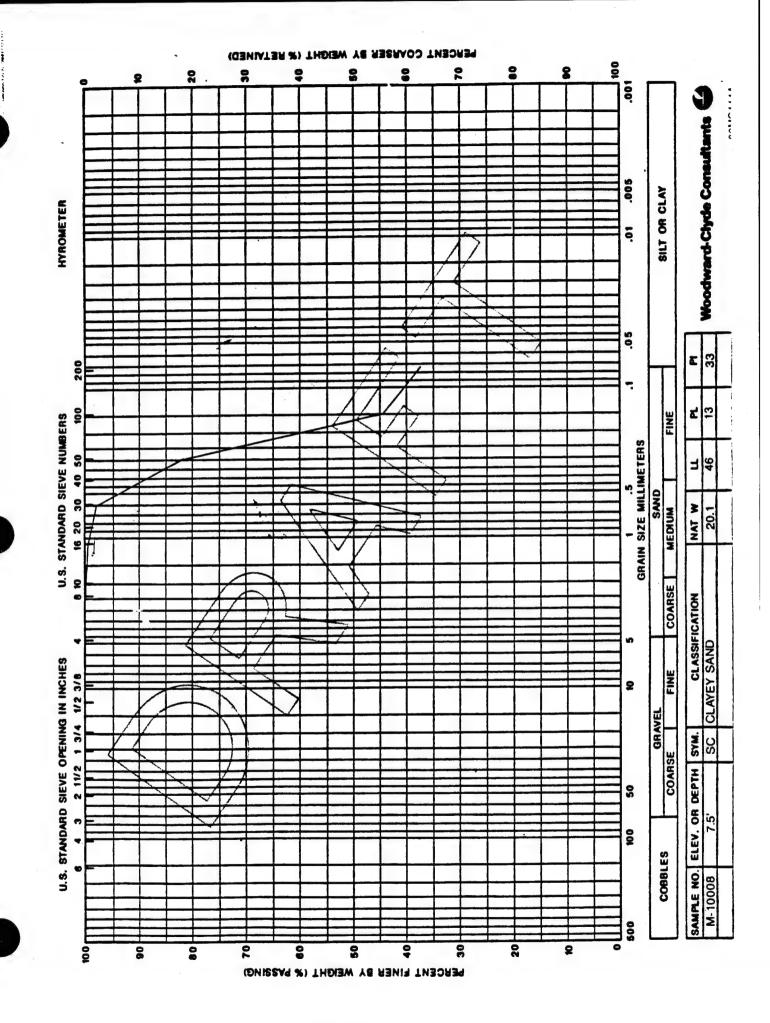




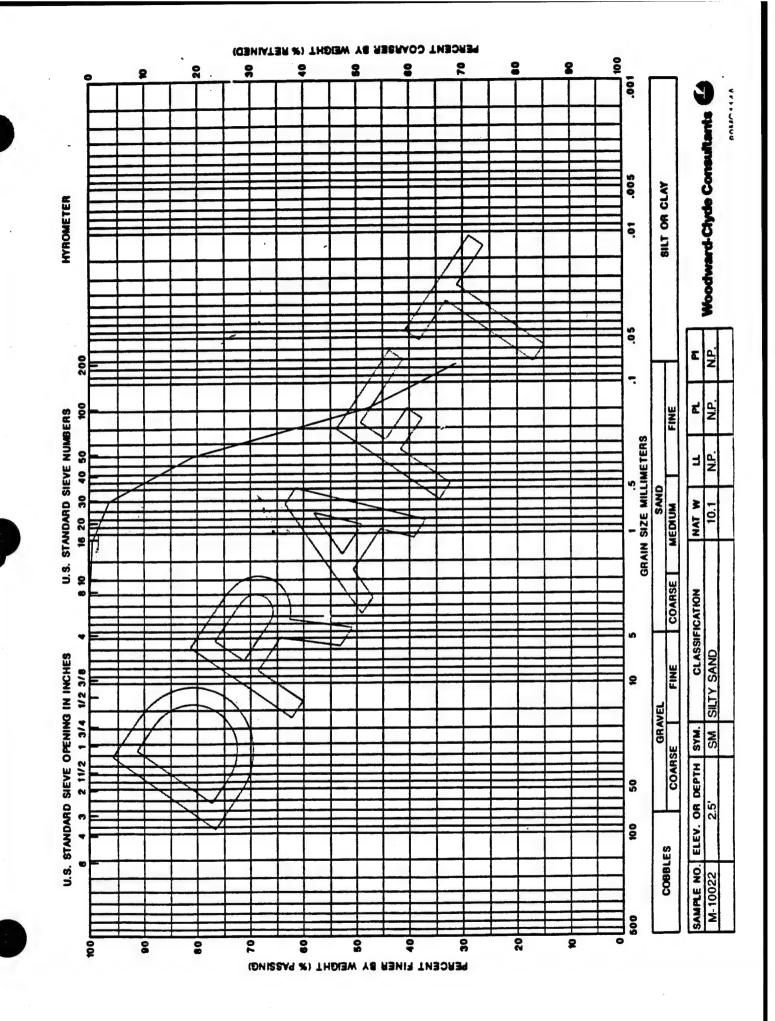


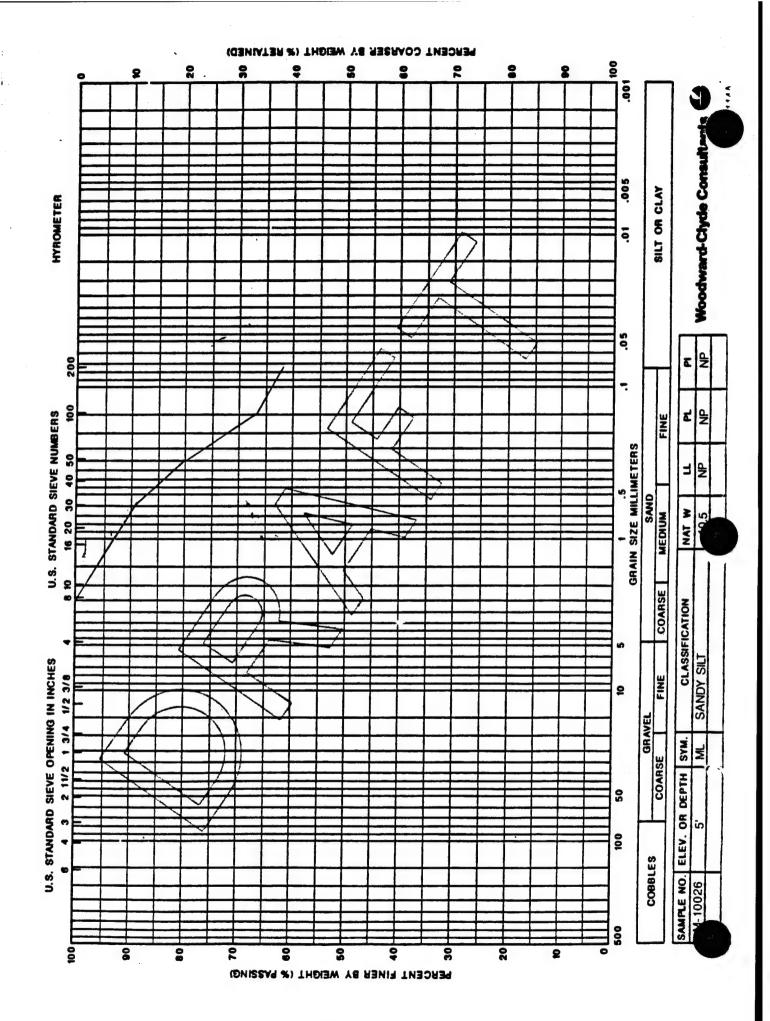






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- \_\_\_\_\_\_, 1990, Final Decision Document for the Interim Response Action at the M-1 Settling Basins, Rocky Mountain Arsenal, Commerce City, Colorado.
- \_\_\_\_\_\_, 1990, Field Investigation, Lime and M-1 Settling Basins Slurry Walls, Rocky Mountain Arsenal, Commerce City, Colorado, Vols I and II.

APPENDIX B
WATER SUPPLY & WASTEWATER COLLECTION

OMAHA DISTRICT	COMPUTATION SHEET	CORPS	OF ENGINEERS
PROJECT	S	HEET NO. /	0F 3
ITEM Cutoff Walls and Cap	for Lime and B	SYTLB	DATE 9/28/90
M-1 Settling Basins -	Liftstation Design C	HKD. BY RAK	DATE 10-10-90

Collection Trench Drain to Aurop Station

Assume Trench Drain flow rate = 5 gpm

Sgpm x 60 mis x 24 m/g = 7,200 gal/day

Size lift Station

Tranch Depth & 24 ft.

:. Minimum Depth of Lift Station = 24 ft

Check Volume => I.D. = 3 ft V= 11(15)<sup>2</sup>(1) x7.481 gal/ft.<sup>3</sup>

V=53gal/ft depth

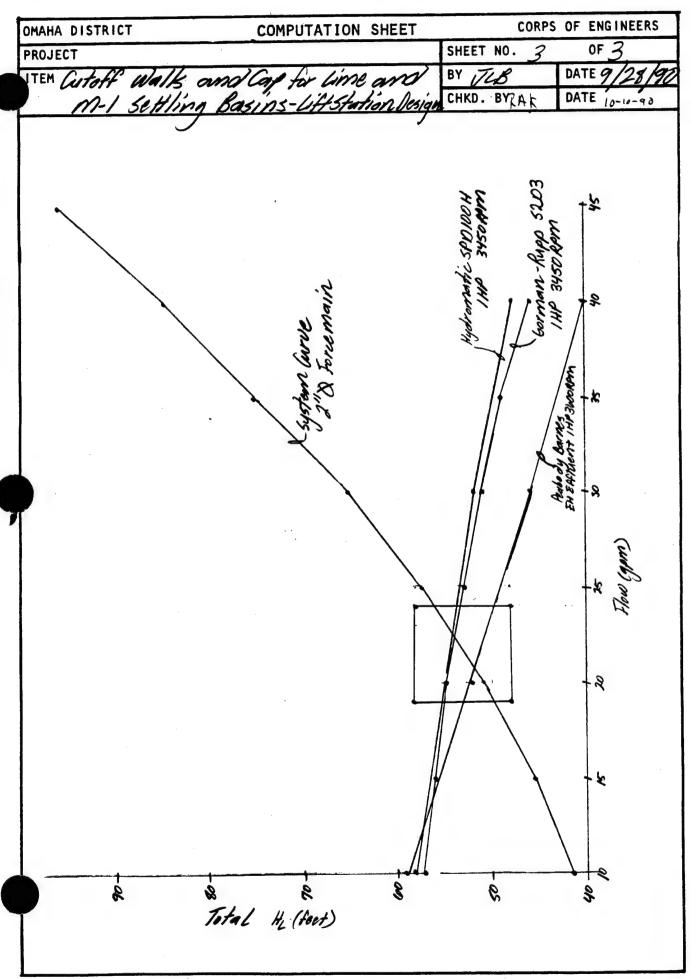
depth of Sump=5ft

Storage Vol. = 5×53 = 265 gallons

Use depth = 38 ft. @ Piam. = 3 ft.

OMAHA DISTRICT	COMPUTATION SHEET	C	ORPS	OF ENG	INEERS
PROJECT		SHEET NO.	2	0F	3
ITEM Cut off Walks a	and Cap for Lime and	BYTLB			128/90
M-1 Settling B	asins - Lift Station Design	CHKD. BY X	CAK	DATE	0-10-90

9		Static H (ft)	Total Heard (ft)
10	3.6	38	41.6
15	7.6	<i>38</i>	45.6
20	12.9	38	50.9
25	19.6	38	57.6
35	27.4	38	65.4
35	34.5	38	74.5
40	46.7	38	84.7
45	58.1	38	96.1



APPENDIX C ELECTRICAL COLLECTIONS

OMAHA DISTRICT	COMPUTA	TION SHEET	C	CORPS OF ENGINEERS		
PROJECT Rocky	Mountain Asseral	Arsenal Lime Basin		/ OF /		
			BY RTL	DATE D. + 1990		
Voltage 1	dust for bout		CHKD. BYLOD	DATE OCT 1990		

Distance 100 feet Load 2Hp notor 10, 240V, 12A Amp-feet = 12A × 100 ft = 1200 A.ft

Using table 5-7-1 in Buss Bulletin SPD81
Electrical Protection Handbook

for # 10 AWG copper in plastic conduit
807. power factor 10 from table 1978

Voltdrop multiply A-ft x table and move decimal point 6 places

Vor., = 1200 x 1978 = 2.373600 = 2.4 V.lts

2.4 v. 1/s/240 v. 1/s = 0.01 = 190 drop

170 is less than 570 maximum and is acceptable.

use # 10 AWG copper for 2HP motor

APPENDIX D

LIST OF PROSPECTIVE GUIDE SPECIFICATIONS

#### LIST OF PROSPECTIVE GUIDE SPECS

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DIVISION	<u>1</u>	9	E	VERAI	REQUIREMENTS
	_		_		

01100	Special Clauses
01200	Warranty of Construction
01300	Environment Protection
01400	Special Safety Requirements

# DIVISION 2 SITE WORK

02050	Demolition
02060	Well Abandonment
02100	Clearing and Grubbing
02150	Hazardous Material Excavation and Handling
02210	Grading
02214	Soil- Bentonite Slurry Trench Cutoffs
02215	Geotextile Filter
02221	Excavation, Trenching, and Backfilling for Utilities Systems
02243	Crushed Rock Surfacing
02244	Low Permeability Cap (Compacted Clay)
02420	Extraction Trench
02480	Seeding
02710	Sewers; Sanitary, Gravity
02713	Water Lines
02724	Force Mains & Extraction Well Piping
02730	Extraction Wells
02910	Monitoring Wells

# DIVISIONS 3 & 4 NOT USED.

# DIVISION 5 METALS

05120	Structural S	Steel
05500	Miscellaneou	us Metal

# DIVISIONS 6 THRU 10 NOT USED.

### DIVISION 11 EQUIPMENT

11303 Guide-Mounted Sewage Lift Stations

# DIVISIONS 12 THRU 15 NOT USED.

#### DIVISION 16 ELECTRICAL

16401	Electrical	Distr	ibution	System,	Aerial
16415	Electrical	Work.	Interio	or	